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PWMA FIELD TEST

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Results of statistical analyses of the data from the field test of a newly developed Portable Wear Metal Analyzer (PWMA) are presented.

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The military services use spectrometric analyses of oil samples from turbine engine aircraft as a tool for preventative maintenance. Normally, the oil samples are sent for analysis to one of several laboratories distributed at various military bases. When aircraft are deployed from their home bases to remote field locations, they are deprived of the benefits of timely oil analysis; for some of the high performance aircraft it has been determined that oil should be analyzed after each flight. The spectrometers that are currently in use are not suitable for deployment with the aircraft because of their bulkiness and their support accessories requirements.

The Air Force awarded a contract to the Perkin-Elmer corporation for the development of a ruggedized, light-weight oil analysis unit that is easily transportable to field locations. A new prototype Portable Wear Metal Analyzer (PWMA) was successfully demonstrated in October 1984. The instrument is packaged in two suitcase like containers that weigh less than 60 pounds each and in laboratory testing it was able to withstand extremes of humidity, temperature and shock. The PWMA can simultaneously analyze and measure the ppm levels of nine wear metals viz., aluminum, chromium, copper, iron, magnesium, nickel, silicon, silver and titanium. The Air Force provided the desired dynamic ranges within which the instrument is required to measure the concentration levels to within one ppm with a repeatability of 2.5%.

The operating principle of the PWMA is the following. An oil sample is injected into a "graphite furnace tube" and is atomized by heating to 3000°C in a preprogrammed ramped cycle. A nine channel polychrometer measures the light energy (emitted by a hollow cathode lamp) absorbance attributable to the atoms of each of the nine wear metals of interest. The absorbance numbers are then converted into concentration levels (in ppm) and printed on a built-in thermal printer; the concentration levels can also be read off of a LED display. The oil sample is injected with an argon-propelled gun; a specially designed disposable plastic tip, attached to the gun, extracts a measured amount of oil sample for analysis. The initial estimate of the useful life of a graphite tube was 160 burns.

The Air Force acquired six copies of the prototype PWMA for testing in an operational environment with military personnel as operators, to assess the suitability of the instrument for the Joint Oil Analysis Program. The Air Force Wright Aeronautical Laboratories (AFWAL) developed a plan for the field test at one Navy location (NARF, Pensacola) and three Air Force oil analysis laboratories (Elmendorf AFB, Langley AFB and Myrtle Beach AFB). One PWMA was retained by AFWAL for internal evaluation and testing and the sixth instrument was to be used as a spare. The plan comprised of testing, at each location, twelve graphite tubes with 160 samples analyzed on each tube, over a four day period at the rate of 40 samples per day. The daily burn sequence was completely specified and included calibration samples (synthesized samples with known concentration levels - 20%, 50%, 100% of the top of the dynamic range - to be used for calibrating the PWMA), verification samples (synthesized samples with known concentration levels - 10%, 40% and 70% of the top of the dynamic range), correlation samples (blend of used oil and synthesized oil, supplied by JOAP-TSC) and random samples (used oil samples from locally based aircraft at each location) to be analyzed in a specified order. On the first and third day of the four day cycle the PWMA was to be "calibrated" and on the second and fourth day a "reslope" operation was required. The calibration process consisted of analyzing the three calibration samples; an internal microprocessor would perform a mathematical analysis to determine the functional relationship (calibration curve) between the measured light absorbance values and the known concentration levels. After calibration, the PWMA produces the concentration levels for any oil sample based on this calibration curve. The reslope is a simplified procedure to fine tune the calibration curve to adjust for any drifts or changes. Most of the oil samples analyzed on the PWMA were also be analyzed on the AE/35U-3 (henceforth Dash-3) atomic emission spectrometer, currently the primary spectrometer in use.

Due to unforeseen scheduling difficulties, breakdowns of the PWMA and other operational constraints, not all bases were able to complete the test exactly according to the plan. The number of graphite tubes tested was different at each of the four locations and there were also differences in the way the data was collected. At one base the PWMA was calibrated each day instead of every other day as required by the plan. If a tube malfunctioned before the completion of a 160 burn sequence, the plan called for the initiation of a fresh 160 burn sequence with a new tube; at one base this requirement was not adhered to and the old test sequence was continued with a new tube. There were also differences in the way samples were drawn for analysis; in some cases the oil bottles were thoroughly shaken before drawing the samples and in other cases this was not done. The point to remember is that these differences may have had a bearing on some of the statistical conclusions reported below.

The data from the field test was sent to us for analysis. We performed statistical tests to examine for (1) consistency of the analytical results between the four instruments (2) stability of the results for different tubes for a fixed instrument (3) differences between the days (significant day to day differences in the observations) for each instrument and tube combination and (4) drifts within a day as the day progressed from morning to afternoon. For the calibration and verification samples we also had available to use the actual light absorbance numbers. We used this absorbance data to check if the calibration algorithm that is programmed into the PWMA's microprocessor could be improved upon to provide more accurate measures of concentration. The measurements for like samples from the PWMA and the AE/35U-3 spectrometer were summarized by computing the means and variances and compared to assess the degree of similarity between the two types of instruments. The data was further analyzed to check if a predictable functional relationship exists between the PWMA measurements and the corresponding emission spectrometer measurements. The underlying reason for this is that if such a relationship were to exist, it can be used to generate decision criteria (criteria for determining when an aircraft engine may require some type of maintenance) for the PWMA, if it were to be selected by the Air Force for oil analysis. This can be achieved by translating the existing Dash-3 threshold wear metal concentration levels into equivalent threshold values for the PWMA based on the established functional relationship. We also examined the data on graphic tube failures to estimate the failure time distribution.

It should be pointed out that practically all of the statistical analyses were performed on the data from the calibration, verification and correlation samples only. The data for the random samples was not used because these samples were very "clean", with many of the concentration numbers zero, rendering them unsuitable for meaningful analyses. Because of this, the oil analysis laboratory at NARF, Pensacola volunteered and collected some additional data on used oil samples, independent of the field test. This data, comprising of corresponding measurements on the PWMA and the emission spectrometer for 20 different used oil samples, replicated five times (five repeated burns for each sample), was used primarily to identify the functional relationship between the measurements for the PWMA and the emission spectrometer, this time for used oil samples.

We now present the results of the statistical analyses; in performing these analyses our aim was to ascertain if statistically significant differences exist a) between the instruments, b) between tubes within any instrument and c) between days wtihin each instrument/tube combination.

Nine correlation samples, prepared by JOAP-TSC were analyzed on all four PWMA's and also with each graphite tube. The means and variances calculated from the data are in Tables 1-9, a separate table for each element. An analysis of variance (F-test) was performed to check for statistically significant differences; an asterisk (*) in a column indicates that the four instruments (four test locations) are significantly different, and a (@) symbol implies that significant differences exist between graphite tubes within each instrument. The analysis of variance tables containing the computed mean squares and F-ratios are included in Tables 10-18. Analogous results for the emission spectrometer are in Tables 19-36; this instrument does not have any replaceable graphite tubes and hence the analysis of variance tests for significant differences between the instruments only.

The field test plan called for analyzing three verification samples every day (twice every alternate day, early and late) on all the PWMA's, with each graphite tube and also on the Dash-3 spectrometer. Analyses of variance on this data indicates that in addition to significant differences between the PWMA's and the graphite tubes, the variability between days, as well the differences between early and late measurements on any day are statistically significant. For the Dash-3 spectrometer, there were significant differences between the instruments as well as between days within instruments, in several cases; see Tables 37 and 38.

In order to provide a comparison of the performances of the PWMA and the Dash-3 spectrometer we prepared two sets of graphs. In the first set (Figures 1-3) we present cross-bar charts of the observed standard deviations for each of the nine correlation samples. The half-width of a horizontal bar represents the standard deviation for the Dash-3 and the vertical half-height measures the standard deviation for the PWMA. The standard deviations (Table 39) were computed by pooling all the available data for each sample. Not all of the graphs contain nine cross-bars; this is because the standard deviations were too small for plotting. It would appear from these graphs that the overall variability for the two types of instruments is comparable. The second set of graphs (Figures 4-6) contain the results of regression analyses to fit straight lines to the PWMA mean and the emission spectrometer mean, for the nine correlation samples. It is clear that a straight line provides a good representation of the relationship between the PWMA measurements and the emission spectrometer measurements. This indicates a "compatibility" between the two types of instruments.

Standard deviation plots and the results of least squares line fitting to the used oil samples data (collected at NARF, Pensacola independent of the field test) are in Table 40 and Figures 7-11. The fitted straight lines appear to provide adequate approximations, but not as good as the results for correlation samples, for all elements except silicon and titanium. The lack of fit for silicon and titanium was primarily due to negligibly small concentration levels. The used oil samples were notall homogeneous; three different base oils of different viscosity were involved. This could, in part account for the lack of fit, for the other elements. A more extensive, controlled experiment will be necessary to measure the relationship, for used oils, between the PWMA and Dash-3.

Next we report on the effort to assess the adequacy of the calibration algorithm programmed into the PWMA's microprocessor; this algorithm fits a rational polynomial equation to the absorbance numbers and the concentration levels for the three calibration samples. We extracted the actual absorbance numbers for the three calibration samples as well as the three verification samples for one of the graphite tubes (all four days) tested at the Langley AFB. Least squares curve fitting techniques were applied to fit an exponential function of the form $y = e^{\alpha+\beta x}$ where x represents the absorbance value and y the corresponding concentration; α and β are unknown parameters to be estimated via least squares. The results, using the pooled data for all four days, are in Figures 12-20. It is clear that the fitted exponential curve tracks the general trend in the relationship between x and y quite well, although there is a certain amount of variability in the horizontal direction; this variability is attributable to the significant day to day differences in the measurements, noted earlier. Figures 22-27 present the results of the same type of analysis for the wearmetals Iron and Silicon except that the data was separated by days and individual curves were fit; a definite improvement in fit is evident. Based on this very limited analysis the following observations appear reasonable. The use of more than three calibration points (we tried six) could result in a more accurate calibration curve. Daily calibration, instead of every other day will have a benificial effect on the PWMA performance. The suitability of mathematical models such as the exponential model for the calibration curve should be explored.

We analyzed the data on the graphite tube failure times (burn numbers) and calculated the median time to failure to be 126 burns. The actual failure times and the causes of failure are listed in Table 39 and the observed cumulative frequency distribution of failure times is in Table 40. It would appear that a reasonable policy is to replace the graphite tube after about 120 burns.

In conclusion, the analysis of the data from the PWMA field test revealed statistically significant differences between the instruments and also between graphite tubes for a fixed instrument. A significant day to day effect as well as a time of day effect was also evident. However, statistically significant differences between the PWMA's does not necessarily imply its unsuitability for SOAP. The determination of the acceptability of the PWMA should be based on realistic accuracy and repeatability criteria desirable for SOAP, the need for a portable oil analyzer, maintainability requirements and of course various cost considerations. It is of interest to note that the measurements from the Dash-3 spectrometer, which is the primary instrument for oil analysis, also exhibited significant differences between the instruments as well as a day to day effect. Another point to remember is that the data collection process was not uniform at the four test sites. As indicated earlier, at some sites the PWMA was calibrated every day and at other sites the instrument was calibrated every other day. The requirement for the initiation of a new 160 burn test sequence each time a graphite tube was replaced, was not adhered to at all bases. There were also differences in the sample selection/injection process. At a debriefing after the conclusion of the field test, it was noted that sample injection gun's trigger can accidentally get squeezed more than once, resulting in a splattering of the sample in and around the graphite tube and this can result in incorrect measurements. All these factors may have had some bearing on the observed differences in the data from the PWMA. It would appear that a combination of a close adherence to the prescribed operating procedures, minor design changes and an improved calibration scheme would improve the PWMA performance.

PWMA values for FE

Tube No	Stat	Correlation Sample Number								
		* 1 ⊠	* 2 ⊠	* 3 ⊠	* 4 ⊠	* 5 ⊠	* 6 ⊠	* 7 ⊠	* 8 ⊠	* 9 ⊠
1	Mean	9.60	28.40	7.00	7.60	26.00	3.00	20.60	4.80	29.20
	StDev	.89	1.95	.00	.55	2.55	.71	3.65	.45	.84
2	Mean	10.20	25.60	7.20	2.60	9.40	3.80	39.20	3.20	17.20
	StDev	.84	.55	.45	.55	.55	.45	4.44	.84	2.77
3	Mean	3.80	12.80	3.80	3.40	15.20	4.40	59.20	5.20	17.80
	StDev	.45	1.30	.84	.89	1.30	.55	31.82	.45	1.10
4	Mean	7.40	15.40	4.60	6.60	23.00	5.20	45.40	2.80	16.20
	StDev	1.34	1.14	.89	1.14	1.87	1.79	4.98	.45	1.10
5	Mean	7.60	17.20	5.00	5.00	19.80	4.40	42.00	8.80	64.20
	StDev	.55	1.79	.71	.00	.45	1.14	4.42	6.87	2.28
7	Mean	7.60	16.20	4.60	6.20	20.80	3.60	37.40	4.60	22.40
	StDev	2.07	2.17	.89	1.10	1.92	.89	8.73	.89	3.51
1	Mean	10.60	27.60	8.60	8.60	19.80	4.20	67.40		
	StDev	1.34	2.41	.55	.55	.45	.45	1.67		
2	Mean	10.40	27.40	8.20	7.20	18.00	3.80			
	StDev	.89	.89	.45	.45	.71	.45			
3	Mean	11.00	25.40	8.20	7.80	17.80				
	StDev	.00	.89	.84	.84	.45				
4	Mean						8.20	76.00		
	StDev						1.10	3.94		
5	Mean	10.40	29.60	8.40	9.00	21.40	4.00	64.00	4.80	18.40
	StDev	.55	.89	.55	.00	.89	.00	10.51	.45	.89
6	Mean	9.80	25.80	3.20	8.40	16.80	4.20	77.20	2.40	15.20
	StDev	.45	.84	.45	3.58	6.26	.45	10.03	.55	.45
7	Mean	9.00	26.40	3.00	5.40	12.40	3.40	72.60	1.80	14.20
	StDev	.00	1.52	.00	.55	.55	.55	2.88	.45	.45
2	Mean	9.20	25.00	5.20	7.00	13.20	4.60	65.60		
	StDev	.45	5.61	3.83	.71	.84	.89	5.03		
3	Mean	11.00	25.40	4.00	5.80	15.60			1.80	24.20
	StDev	.71	2.61	.00	.45	9.21			.45	1.10
4	Mean						3.20	72.60	2.00	18.80
	StDev						.45	5.32	.00	1.30
5	Mean	8.60	27.40	3.00						
	StDev	.55	2.70	.00						
6	Mean				6.00	18.60	3.80	71.00		
	StDev				.71	2.30	.45	6.89		
1	Mean	11.00	30.40	9.00	9.60	22.60	3.20	89.20	3.20	26.60
	StDev	.00	3.44	.00	.89	2.41	.45	1.30	.45	1.95
3	Mean	9.80	30.00	8.40	9.20	23.20	3.80	72.00	5.00	29.20
	StDev	1.30	1.22	.55	.84	2.17	.45	4.74	.00	1.64
4	Mean	9.20	30.00	14.40						
	StDev	.84	.71	6.80						
5	Mean	8.20	29.20	8.00	7.40	26.20	3.00	76.40	4.60	26.00
	StDev	.45	.45	.00	.55	.84	.00	1.95	.55	[illegible]
6	Mean	9.60	28.00	8.00	7.80	21.80	3.20	66.60	6.80	30.40
	StDev	.55	.71	.00	.45	.84	.45	3.05	.84	4.16
8	Mean	7.60	28.40	6.00	7.20	24.00	3.80	82.60	4.60	27.60
	StDev	.55	1.14	.00	.45	.00	.45	4.88	.55	.89
9	Mean	10.40	28.80	11.00	9.40	19.20	3.40	82.60	4.20	22.80
	StDev	1.14	3.49	5.05	.55	.45	.55	7.83	.45	1.48
12	Mean	11.00	28.40	7.00	8.00	20.40	4.20	71.80	5.80	32.00
	StDev	.71	.55	.00	.00	.89	.45	.45	.84	4.64
13	Mean	12.80	28.60	8.80	9.20	22.20	5.60	79.60	7.20	29.60
	StDev	1.10	.55	.45	2.17	.45	.55	8.32	1.30	3.21
15	Mean	9.20	27.20	9.00	8.00	21.00	3.40	57.80	6.60	26.40
	StDev	.45	.84	.00	.00	.00	.55	7.85	1.34	4.39
16	Mean	13.40	31.00	8.00	9.00	21.00	3.40	78.80	6.80	35.60
	StDev	1.14	2.24	.00	1.41	.00	.55	6.10	.84	1.10

des by Sample Numbers: * means Lab differences. ⊠ means Tube differences

TABLE 1

FWMA values for AG

Lab	Tube No	Stat	Correlation Sample Number * 1 @	* 2 @	* 3 @	* 4 @	* 5 @	* 6 @	7	8	9
Elm	1	Mean	7.20	11.80	16.00	12.20	5.00	9.60	.00	.00	
		StDev	1.10	.45	.00	1.30	1.00	1.34	.00	.00	
	2	Mean	5.60	11.60	11.20	2.40	2.00	8.00	.00	.00	
		StDev	.55	.55	.45	.55	.00	.00	.00	.00	
	3	Mean	2.60	8.40	10.60	3.60	3.00	10.80	.00	.00	
		StDev	.55	1.14	1.82	.89	.71	.45	.00	.00	
	4	Mean	3.20	6.40	9.40	4.20	3.80	9.00	.00	.00	
		StDev	.84	1.14	3.21	1.10	.45	1.87	.00	.00	
	5	Mean	3.40	9.80	10.60	4.60	3.80	9.20	.00	.00	
		StDev	.55	1.30	.89	.89	.45	1.10	.00	.00	
	7	Mean	3.40	7.20	9.40	4.20	3.40	7.00	.00	.00	
		StDev	.89	1.64	1.14	1.10	.55	1.87	.00	.00	
Lan	1	Mean	5.00	11.80	12.00	10.00	4.00	9.20	.00		
		StDev	.00	.45	.00	.00	.00	.45	.00		
	2	Mean	4.80	11.40	12.00	9.00	4.00	7.60			
		StDev	.45	.89	.00	.71	.00	.55			
	3	Mean	5.00	11.00	12.40	8.40	3.80				
		StDev	.00	.00	.89	1.52	.45				
	4	Mean						9.80	.00		
		StDev						1.10	.00		
	5	Mean	4.80	11.20	11.20	9.00	4.00	8.60	.00	.00	
		StDev	.45	.45	.45	.00	.71	.55	.00	.00	
	6	Mean	6.00	11.80	11.40	9.20	1.00	10.00	.00	.00	
		StDev	.71	.45	.55	.84	.00	.00	.00	.00	
	7	Mean	5.00	11.60	11.40	8.60	1.60	8.20	.00	.00	
		StDev	.00	.55	1.52	.89	.55	1.64	.00	.00	
MvB	2	Mean	4.60	10.80	9.80	9.40	.60	10.00	.00		
		StDev	.55	.45	.45	.89	.55	.00	.00		
	3	Mean	4.80	9.20	11.60	9.00	.40			.00	
		StDev	.45	1.30	.89	.71	.55			.00	
	4	Mean						10.20	.00	.00	
		StDev						.45	.00	.00	
	5	Mean	5.60	10.60	11.80						
		StDev	.55	1.82	2.68						
	6	Mean				10.80	3.80	9.40	.00		
		StDev				.45	.45	1.95	.00		
Pns	1	Mean	5.00	11.60	12.00	10.40	4.00	9.00	.00	.00	
		StDev	.00	1.14	.71	.55	.00	1.00	.00	.00	
	3	Mean	4.00	10.20	11.00	8.40	4.00	8.60	.00	.00	
		StDev	.00	.45	.00	1.14	.00	.55	.00	.00	
	4	Mean	6.80	12.00	14.00						
		StDev	2.28	.00	1.22						
	5	Mean	6.40	12.20	14.40	10.60	5.20	11.00	.00	.00	
		StDev	.55	.45	4.83	.55	.45	1.00	.00	.00	
	6	Mean	5.00	11.00	11.00	8.00	4.00	10.00	.00	.00	
		StDev	.00	.00	.00	.00	.00	.00	.00	.00	
	8	Mean	6.00	12.20	12.00	11.20	8.60	11.00	.00	.00	
		StDev	.00	.45	.00	.45	.55	.00	.00	.00	
	9	Mean	9.80	12.40	16.00	11.80	4.00	9.60	.00	.00	
		StDev	1.10	1.52	.00	.45	.00	1.34	.00	.00	
	12	Mean	7.20	11.80	11.40	11.00	5.00	11.00	.00	.00	
		StDev	.45	.45	.55	.00	.00	.00	.00	.00	
	13	Mean	8.60	11.60	14.40	11.20	5.00	8.20	.00	.00	
		StDev	.55	.55	.89	1.10	.00	.45	.00	.00	
	15	Mean	6.20	11.00	12.60	7.60	4.00	9.80	.00	.00	
		StDev	.45	.00	.55	.55	.00	.45	.00	.00	
	16	Mean	10.20	11.60	14.80	9.80	4.00	6.20	.00	.00	
		StDev	.84	.89	.45	.84	.00	.45	.00	.00	

Codes of Sample Numbers: * means Lab differences. @ means Tube differences

TABLE 2

PWMA values for **AL**

Tube No	Stat	Correlation Sample Number * 1 ⊠	* 2	* 3 ⊠	* 4 ⊠	5 ⊠	6 ⊠	* 7 ⊠	* 8 ⊠	* 9 ⊠
1	Mean	22.00	11.80	10.00	14.80	1.00	16.00	13.60	32.60	18.40
	StDev	7.91	6.18	9.77	2.59	.00	11.27	3.44	4.28	2.30
2	Mean	14.80	5.20	3.80	2.40	1.00	6.60	13.40	20.20	16.60
	StDev	3.77	.45	.45	.55	.00	2.07	3.65	5.81	10.31
3	Mean	8.40	3.20	5.80	4.80	2.60	9.40	24.20	36.60	14.00
	StDev	1.52	1.10	1.64	.45	.55	2.19	15.29	2.70	2.45
4	Mean	9.00	5.00	6.40	5.00	4.40	10.60	10.80	26.60	15.20
	StDev	1.73	.71	2.07	.71	.89	5.32	1.48	5.37	7.40
5	Mean	9.60	5.00	6.40	7.00	4.80	7.20	10.60		
	StDev	1.67	.71	1.52	1.22	1.10	.45	1.14		
7	Mean	14.80	4.20	5.00	4.20	3.20	12.40	10.00	26.20	10.40
	StDev	8.90	1.64	.71	.84	.84	9.37	1.22	9.96	.55
1	Mean	18.60	7.20	11.00	11.20	5.00	10.80	22.20		
	StDev	4.39	1.30	1.22	1.30	1.00	2.59	1.10		
2	Mean	11.20	7.20	8.40	15.60	7.20	13.00			
	StDev	.84	.84	.55	2.30	1.30	8.40			
3	Mean	14.40	6.40	11.60	8.80	6.20				
	StDev	2.07	1.82	3.13	2.17	1.30				
4	Mean						17.00	21.40		
	StDev						1.87	.89		
5	Mean	21.20	12.60	6.20	12.80	4.80	6.00	21.80	33.80	13.20
	StDev	3.03	11.97	.84	4.27	.84	.00	2.17	.84	4.38
6	Mean	14.20	6.40	7.20	9.80	2.80	11.60	16.00	21.40	11.80
	StDev	7.22	1.14	.45	1.30	.45	1.52	.71	3.05	.84
7	Mean	23.40	4.20	14.40	14.20	1.80	8.40	26.60	21.80	17.00
	StDev	6.54	.84	3.21	.84	.45	6.07	3.58	1.30	2.92
2	Mean	23.40	11.40	14.60	14.80	1.40	15.00	28.60		
	StDev	5.77	11.24	1.95	1.10	.55	1.00	1.52		
3	Mean	16.80	11.00	9.00	13.60	10.20			16.20	12.40
	StDev	1.48	1.00	1.22	3.21	12.76			1.92	4.34
4	Mean						8.00	22.00	17.00	11.40
	StDev						4.24	4.06	4.69	2.30
5	Mean	15.80	14.40	13.60						
	StDev	1.10	6.11	1.14						
6	Mean				11.20	3.40	10.20	27.40		
	StDev				5.76	1.14	6.30	2.30		
1	Mean	9.80	7.20	6.60	9.20	5.40	16.40	27.40	23.20	18.00
	StDev	2.17	2.17	1.34	1.79	1.14	8.17	3.58	4.55	5.52
3	Mean	9.80	8.60	8.00	10.00	4.60	12.40	16.60	36.20	27.00
	StDev	3.90	3.78	3.74	2.92	1.34	1.95	1.52	4.32	4.64
4	Mean	12.00	9.80							
	StDev	1.00	1.64							
5	Mean	19.60	6.80	13.40	12.20	4.80	14.20	32.60	23.80	15.40
	StDev	6.80	3.49	5.94	4.15	.84	1.30	3.51	4.66	2.79
6	Mean	8.80	9.60	11.40	9.80	4.00	10.80	32.40	27.80	21.40
	StDev	3.83	1.34	1.52	1.92	.71	.84	.89	2.68	4.39
8	Mean	14.00	8.60	10.00	11.00	4.60	8.00	23.00	16.80	14.00
	StDev	2.12	.55	.71	.71	.55	1.41	5.96	2.59	.71
9	Mean	19.80	8.80	7.80	9.60	4.00	13.40	26.40	19.40	20.80
	StDev	7.43	1.10	.45	.89	.00	1.34	2.70	5.22	3.03
12	Mean	14.00	13.00	13.80	11.60	2.20	9.40	20.40	22.20	22.20
	StDev	8.28	4.47	4.49	2.70	.45	1.34	2.61	6.87	6.69
13	Mean	10.20	8.00	9.20	12.20	4.20	13.80	24.40	23.20	19.40
	StDev	.84	1.87	1.30	11.67	.45	4.15	7.60	8.61	3.91
15	Mean	8.60	8.60	9.00	7.60	3.80	14.20	22.20	27.00	23.40
	StDev	1.82	1.95	.71	1.52	.45	2.17	6.18	4.85	5.72
16	Mean	12.80	9.60	8.20	11.20	4.80	16.80	26.40	16.80	15.90
	StDev	1.30	.55	.84	.45	.84	1.92	1.52	2.49	3.33

des by Sample Numbers: * means Lab differences, ⊠ means Tube differences

TABLE 3

PWMA values for CU

Lab	Tube No	Stat	Correlation Sample Number * 1 ▩	* 2 ▩	* 3 ▩	* 4 ▩	5	* 6 ▩	* 7 ▩	* 8 ▩	* 9
Elm	1	Mean	35.40	11.00	53.00	9.20	4.80	10.80	13.80	39.80	39.
		StDev	3.71	.71	1.22	.84	.45	2.17	2.77	2.49	1.
	2	Mean	27.80	9.40	40.60	3.40	13.40	8.80	27.60	18.20	21.
		StDev	1.64	.55	.55	.55	25.49	.84	3.29	2.59	.
	3	Mean	15.80	5.40	34.00	4.00	3.20	11.80	42.20	23.60	22.
		StDev	3.11	.55	8.34	1.41	.84	.45	23.34	11.57	1.
	4	Mean		5.00	28.00	5.20	4.20	9.40	31.60	19.00	20.
		StDev		1.00	10.30	1.10	.45	2.30	4.04	2.35	3.
	5	Mean	19.00	8.00	30.80	6.20	4.20	11.00	30.00		73.
		StDev	1.00	.71	2.59	.84	.45	1.41	3.74		2.
	7	Mean	19.00	5.00	27.80	4.80	3.80	10.00	26.20	21.20	24.
		StDev	4.74	1.00	3.35	.84	.45	4.53	9.42	2.49	6.
Lan	1	Mean	29.00	10.80	40.00	10.60	5.00	12.40	41.60		
		StDev	3.39	.84	1.00	.55	.00	.55	1.52		
	2	Mean	27.40	9.80	41.40	8.40	3.80	11.20			
		StDev	2.19	.45	.89	.55	.45	.84			
	3	Mean	40.80	10.00	52.20	7.80	3.60				
		StDev	1.79	.00	5.63	.84	.55				
	4	Mean						16.60	42.80		
		StDev						.55	.45		
	5	Mean	28.80	11.00	42.40	9.20	4.20	10.00	33.80	21.60	20.
		StDev	1.10	.71	2.97	.45	.45	.71	5.36	1.14	.
	6	Mean	27.40	9.80	32.80	7.60	3.00	13.00	46.60	21.60	17.
		StDev	1.34	.45	1.30	.89	.00	1.22	8.62	6.39	.
	7	Mean	29.00	10.00	33.80	9.00	3.80	11.00	45.00	18.00	16.
		StDev	5.61	.00	7.56	.71	.45	1.41	1.87	1.87	.
MvB	2	Mean	30.80	9.40	35.60	8.80	3.20	12.60	40.20		
		StDev	1.92	.89	2.97	.84	.45	.55	2.17		
	3	Mean	29.00	9.60	44.40	8.20	2.60			22.00	33.
		StDev	5.34	.89	2.07	.84	.55			1.22	1.
	4	Mean						11.00	41.00	21.80	23.
		StDev						.71	3.74	.84	1.
	5	Mean	28.20	10.00	33.40						
		StDev	1.64	2.83	8.08						
	6	Mean				8.60	4.00	11.40	43.00		
		StDev				.55	.00	.55	1.41		
Pns	1	Mean	35.20	10.60	46.00	10.60	4.40	11.40	44.20	33.60	32.
		StDev	.84	.89	1.22	1.34	.55	1.34	.84	4.39	3.
	3	Mean	22.80	9.60	37.40	9.60	4.00	11.40	41.80	40.40	40.
		StDev	1.10	.55	.55	.89	.00	1.14	.84	1.14	2.
	4	Mean	31.80	10.00	60.80						
		StDev	4.92	.00	17.77						
	5	Mean	29.00	10.40	44.40	9.60	5.00	11.60	41.40	37.00	35.
		StDev	1.22	.55	5.37	.55	.00	.55	1.14	1.00	1.
	6	Mean	26.40	9.60	36.80	8.20	4.00	11.20	41.00	39.40	33.
		StDev	.89	.55	1.30	.45	.00	.45	.00	3.05	5.
	8	Mean	27.40	9.60	40.80	9.40	5.00	12.00	47.40	28.40	29.
		StDev	.55	.55	.45	.55	.00	.71	4.28	1.14	.
	9	Mean	37.80	9.80	51.40	10.40	4.20	11.00	48.00	27.00	27.
		StDev	5.26	1.30	.89	.55	.45	1.22	1.00	2.92	1.
	12	Mean	32.40	10.00	39.60	9.60	4.80	12.40	43.00	37.60	40.
		StDev	2.07	.71	.55	.55	.84	.89	.00	4.77	2.
	13	Mean	39.80	9.20	51.80	12.40	4.80	12.40	49.80	29.80	28.
		StDev	3.27	.45	3.96	6.02	.45	.55	4.21	5.72	1.
	15	Mean	28.20	9.40	49.80	7.40	3.60	10.60	41.80	49.80	49.
		StDev	.45	.55	1.30	.55	.55	.55	3.35	2.77	1.
	16	Mean	39.60	10.60	51.00	8.60	4.60	10.00	39.40	32.80	32.
		StDev	1.52	.89	.71	.89	.55	.00	2.97	.84	.

Codes by Sample Numbers: * means Lab differences. ▩ means Tube differences

TABLE 5

FWMA values for CR:

Tube No	Stat	Correlation Sample Number * 1 ⊞	* 2 ⊞	* 3 ⊞	* 4 ⊞	* 5 ⊞	* 6 ⊞	* 7 ⊞	* 8 ⊞	* 9 ⊞
1	Mean	6.80	7.20	1.60	8.80	9.80	5.00	1.00	1.20	1.00
	StDev	1.92	.84	.55	.84	1.10	1.22	.00	.45	.00
2	Mean	8.00	9.00	2.00	3.20	5.00	3.60	1.20	1.00	1.00
	StDev	1.22	1.00	.00	.84	.71	.55	.45	.00	.00
3	Mean	3.80	5.20	1.00	4.20	9.60	4.80	1.60	1.00	1.00
	StDev	.45	.84	.00	.84	.55	.45	.55	.00	.00
4	Mean	4.40	4.20	1.20	4.80	10.40	3.80	1.40	1.00	1.00
	StDev	.89	.45	.45	.84	.55	.84	.55	.00	.00
5	Mean	4.80	5.80	1.00	4.20	8.20	4.20	2.00	1.80	3.00
	StDev	.45	.84	.00	.45	.45	.45	.00	1.30	.00
7	Mean	5.00	4.60	1.00	4.40	9.40	3.20	1.40	1.20	1.20
	StDev	1.22	.55	.00	.89	.89	.45	.55	.45	.45
1	Mean	9.20	10.60	2.00	10.80	11.60	5.00	2.00		
	StDev	1.10	.55	.00	.45	.55	.00	.00		
2	Mean	7.00	7.40	2.00	8.60	10.40	4.60			
	StDev	1.00	.55	.00	.55	.55	.55			
3	Mean	7.20	9.60	2.00	9.00	11.00				
	StDev	.45	.55	.00	1.22	.00				
4	Mean						6.00	3.80		
	StDev						.00	.45		
5	Mean	7.80	8.40	2.00	9.80	9.60	4.00	2.00	2.00	1.00
	StDev	.45	1.14	.00	.45	.55	.00	.00	.00	.00
6	Mean	6.20	7.40	1.00	9.00	9.60	5.00	2.00	.40	.00
	StDev	.45	1.14	.00	.00	1.52	.00	.00	.55	.00
7	Mean	6.00	7.40	1.00	9.40	9.60	5.20	2.00	.00	.00
	StDev	2.92	1.14	.00	.55	.55	.45	.00	.00	.00
2	Mean	8.00	8.00	1.00	10.40	10.80	5.00	2.00		
	StDev	.71	2.00	.00	.55	.45	.00	.00		
3	Mean	7.00	8.00	1.00	10.60	10.80			.00	1.00
	StDev	1.00	.71	.00	.55	.84			.00	.00
4	Mean						5.00	2.40	.20	.20
	StDev						.71	.55	.45	.45
5	Mean	6.80	8.00	1.00						
	StDev	.45	.71	.00						
6	Mean				8.80	11.20	5.00	2.00		
	StDev				1.48	.84	.00	.00		
1	Mean	6.20	8.20	2.00	11.00	11.60	5.60	2.40	1.00	1.00
	StDev	.84	1.48	.00	.71	.55	.55	.55	.00	.00
3	Mean	6.80	8.20	2.00	11.20	11.00	5.00	2.20	2.00	2.00
	StDev	.45	.45	.00	.45	.00	.00	.45	.00	.00
4	Mean	7.40	9.40	3.00						
	StDev	.55	.89	1.00						
5	Mean	8.00	8.00	2.20	10.20	10.20	5.00	2.00	1.60	1.00
	StDev	.71	1.22	.45	.84	.45	.00	.00	.55	.00
6	Mean	7.00	8.60	2.00	10.00	10.20	5.00	2.40	2.00	1.40
	StDev	.00	1.67	.00	.00	.45	.00	.55	.00	.55
8	Mean	7.00	9.00	2.00	10.20	10.20	5.00	2.00	1.60	1.00
	StDev	1.00	.71	.00	.45	.84	.00	.00	.55	.00
9	Mean	8.00	8.80	2.40	11.20	11.00	5.00	3.00	2.00	1.40
	StDev	1.00	.84	.89	.84	.71	.00	.00	.00	.55
12	Mean	8.20	8.80	2.20	9.80	10.00	4.80	2.40	1.80	1.00
	StDev	.84	.84	.45	.45	.00	.45	.55	.45	.00
13	Mean	7.80	9.00	2.00	10.40	10.20	5.00	2.80	2.00	1.60
	StDev	.84	1.00	.00	.89	1.30	.00	.45	.00	.89
15	Mean	8.20	9.00	2.00	9.40	10.00	4.80	2.20	2.00	1.00
	StDev	.45	.00	.00	.55	.00	.45	.45	.00	.00
16	Mean	7.40	8.60	2.00	9.80	9.80	5.00	2.40	2.00	1.60
	StDev	.55	.55	.00	.45	.45	.00	.55	.00	.55

es by Sample Numbers: * means Lab differences. ⊞ means Tube differences

TABLE 4

PWMA values for **MG**

Lab	Tube No	Stat	Correlation Sample Number * 1 ⊠	* 2 ⊠	* 3 ⊠	* 4 ⊠	* 5 ⊠	* 6 ⊠	* 7 ⊠	* 8 ⊠	* 9
Elm	1	Mean	4.00	8.00	29.60	5.00	28.40	1.20	3.20	21.80	27.
		StDev	1.22	1.41	1.52	.71	.55	.45	.45	3.90	.
	2	Mean	2.40	6.00	28.60	1.80	12.00	1.00	7.60	26.40	26.
		StDev	.55	.00	.55	.45	2.12	.00	1.95	.89	.
	3	Mean	2.80	4.60	21.60	2.80	22.20	1.00	6.80	7.60	22.
		StDev	.45	.55	5.41	.45	2.77	.00	1.64	.55	2.
	4	Mean	3.60	5.40	20.60	3.80	27.60	1.20	8.00	25.60	24.
		StDev	.89	.55	6.39	.84	.89	.45	.71	.89	.
	5	Mean	4.40	6.20	20.40	4.00	17.00	1.40	7.00	28.80	31.
		StDev	.55	.45	3.65	.00	2.35	.55	.00	6.83	2.
	7	Mean	4.40	5.40	22.20	3.60	26.80	1.20	8.20	27.60	30.
		StDev	1.14	.89	3.56	.89	1.30	.45	1.10	.89	1.
Lan	1	Mean	3.80	13.00	30.40	8.60	29.40	1.80	11.80		
		StDev	.84	1.41	.89	.89	.55	.45	.45		
	2	Mean	3.60	10.00	28.00	7.40	27.00	2.80			
		StDev	.55	1.00	.71	.55	.71	2.39			
	3	Mean	5.00	10.60	27.20	5.80	26.00				
		StDev	.00	1.14	.45	1.30	.71				
	4	Mean						1.20	7.20		
		StDev						.45	.45		
	5	Mean	3.20	9.00	27.80	8.20	28.00	1.00	11.80	23.80	28.
		StDev	.45	.00	.45	.45	1.00	.00	.84	.84	.
	6	Mean	4.00	9.60	27.20	7.40	26.40	1.40	10.80	24.20	26.
		StDev	1.41	.55	.45	1.14	.55	.55	1.92	2.17	.
	7	Mean	4.60	8.40	27.80	8.20	26.60	1.00	13.80	25.80	27.
		StDev	1.52	1.14	.45	.45	.55	.00	1.10	.45	.
MvB	2	Mean	8.40	10.00	29.80	8.20	28.20	1.00	7.40		
		StDev	1.67	4.30	.84	2.05	.84	.00	.89		
	3	Mean	4.00	10.60	28.40	5.60	27.20			28.20	28.
		StDev	1.41	3.13	.55	.89	2.17			.45	1.
	4	Mean						1.00	10.80	29.00	31.
		StDev						.00	7.53	.71	1.
	5	Mean	4.00	15.00	29.40						
		StDev	1.73	8.15	1.34						
	6	Mean				4.60	29.00	1.20	14.40		
		StDev				.89	1.58	.45	7.27		
Pns	1	Mean	5.40	13.60	25.40	10.60	23.20	2.00	16.60	25.60	27.
		StDev	.55	1.14	.55	3.13	1.30	.00	.55	.55	.
	3	Mean	4.20	16.20	27.00	14.60	22.40	2.00	16.40	26.40	26.
		StDev	.45	2.68	.00	3.71	1.52	.00	.55	.55	.
	4	Mean	7.20	17.40	39.20						
		StDev	.45	1.34	10.80						
	5	Mean	6.80	16.20	31.40	13.40	26.00	2.00	17.60	26.20	28.
		StDev	1.30	1.64	5.98	2.97	.71	.00	.55	1.10	.
	6	Mean	4.80	14.00	27.20	10.00	25.40	1.80	13.80	17.60	24.
		StDev	.45	1.41	.45	.00	.89	.45	.84	1.52	1.
	8	Mean	6.00	11.80	27.20	11.80	26.80	1.00	17.60	24.00	26.
		StDev	.00	1.10	.45	1.64	.45	.00	1.82	.00	.
	9	Mean	5.60	14.00	27.60	10.80	26.00	1.80	18.60	26.00	29.
		StDev	1.52	.00	.89	1.10	.00	.45	2.61	.71	.
	12	Mean	6.00	12.80	27.00	10.60	27.80	2.00	16.80	26.60	29.
		StDev	.71	1.30	.00	.55	.45	.00	1.10	1.14	.
	13	Mean	6.80	13.40	26.40	14.00	26.60	1.80	17.20	25.40	27.
		StDev	.45	.55	.55	8.43	.55	.45	3.27	1.52	.
	15	Mean	5.00	13.40	27.00	10.60	24.20	1.20	15.00	26.80	28.
		StDev	.00	.55	.00	.55	1.48	.45	1.41	.84	.
	16	Mean	5.20	12.00	26.60	10.20	26.60	1.00	15.80	16.00	20.
		StDev	.45	1.00	.55	1.64	.55	.00	.84	1.87	1.

Codes by Sample Numbers: * means Lab differences. ⊠ means Tube differences

TABLE 6

PWMA values for NI

Tube No	Stat	Correlation Sample Number								
		* 1 ⊠	* 2 ⊠	* 3 ⊠	* 4 ⊠	* 5 ⊠	* 6 ⊠	* 7 ⊠	* 8 ⊠	* 9 ⊠
1	Mean	6.80	12.20	29.40	9.20	4.40	15.60	7.20	5.20	12.00
	StDev	.45	.45	1.34	.45	.55	2.30	.84	.45	.00
2	Mean	8.00	11.80	32.20	3.60	2.00	11.60	9.40	3.00	7.00
	StDev	.00	.45	.45	.55	.00	.55	.89	.00	.00
3	Mean	3.80	6.40	22.80	4.20	3.00	14.00	11.00	6.00	9.80
	StDev	.45	.55	5.36	.84	.00	.71	3.67	.00	.45
4	Mean	5.20	6.80	20.20	6.20	4.00	13.00	9.80	3.00	6.40
	StDev	.84	.84	6.42	.84	.00	2.35	.84	.71	.55
5	Mean	5.20	8.40	20.00	5.40	3.00	12.80	11.00	6.20	19.00
	StDev	.45	.89	1.87	.55	.00	1.30	1.00	2.68	.71
7	Mean	5.80	7.20	19.80	5.80	3.80	10.60	9.00	4.00	8.00
	StDev	.84	1.10	1.64	.84	.45	1.14	1.58	.71	1.22
1	Mean	8.00	12.20	36.00	9.40	4.00	14.40	15.80		
	StDev	.00	.45	.00	.55	.00	.55	.45		
2	Mean	8.00	13.00	33.40	9.40	4.00	14.00			
	StDev	.00	2.24	.55	.55	.00	.00			
3	Mean	7.00	11.80	30.40	9.20	4.00				
	StDev	.00	.45	1.14	.45	.00				
4	Mean						16.00	17.00		
	StDev						.71	.71		
5	Mean	8.00	12.40	33.00	10.00	4.00	14.00	15.80	5.00	9.00
	StDev	.00	.55	1.22	.00	.00	.00	.45	.00	.00
6	Mean	7.60	11.60	33.40	8.00	3.00	14.20	16.00	5.40	9.00
	StDev	.55	.55	.89	.71	.00	.45	.71	.55	.00
7	Mean	6.80	12.20	31.60	8.20	3.00	14.60	14.80	4.40	8.00
	StDev	.45	.45	3.78	.45	.00	.55	.45	.55	.00
2	Mean	7.20	11.80	31.20	9.20	3.00	14.20	14.80		
	StDev	.45	1.30	1.48	.84	.00	.45	1.30		
3	Mean	7.80	11.20	31.40	8.80	3.00			5.20	12.00
	StDev	.45	.45	.55	.45	.00			.45	.00
4	Mean						14.80	15.00	5.00	10.00
	StDev						.45	.71	.00	.00
5	Mean	7.20	11.80	32.40						
	StDev	.45	1.30	1.14						
6	Mean				9.20	3.80	16.00	14.80		
	StDev				.84	.45	.71	.84		
1	Mean	7.00	12.00	29.80	8.20	4.00	16.40	15.00	5.80	11.60
	StDev	.00	.00	2.28	.45	.00	.89	.00	.45	.55
3	Mean	8.60	13.00	32.20	10.20	4.80	14.80	16.00	6.20	11.40
	StDev	.55	.00	.45	.45	.45	.45	.00	.45	.89
4	Mean	7.40	13.00	33.80						
	StDev	.55	.00	2.28						
5	Mean	8.00	12.00	34.40	9.00	4.00	15.40	15.40	5.20	10.80
	StDev	.00	.00	4.83	.00	.00	.55	.55	.45	.45
6	Mean	8.00	12.00	32.00	9.00	4.00	15.00	15.60	6.00	11.70
	StDev	.00	.00	.00	.00	.00	.00	.55	.00	.45
8	Mean	8.00	12.60	32.00	9.80	4.00	16.40	15.80	6.20	12.80
	StDev	.00	.55	.00	.45	.00	.55	1.30	.45	.45
9	Mean	7.40	12.20	30.60	9.00	4.00	14.40	14.80	5.20	10.40
	StDev	.55	.45	.55	.00	.00	.55	.84	.45	.55
12	Mean	8.00	12.80	32.20	9.60	4.00	14.00	15.40	5.60	10.60
	StDev	.00	.45	.45	.55	.00	.00	.55	.55	.55
13	Mean	8.00	12.00	28.80	9.40	4.00	15.00	14.60	6.20	11.00
	StDev	.00	.00	3.49	.55	.00	.00	.89	.45	.00
15	Mean	8.00	12.00	31.00	9.00	4.00	13.80	14.60	6.80	11.80
	StDev	.00	.00	.00	.00	.00	.45	.89	.84	.45
16	Mean	8.00	12.00	30.80	9.20	4.00	15.20	16.20	8.20	11.80
	StDev	.00	.00	.45	.45	.00	.45	.45	2.95	.84

des by Sample Numbers: * means Lab differences. ⊠ means Tube differences

TABLE 7

FWMA values for SI

Lab	Tube No	Stat	Correlation Sample Number 1	2	* 3 ⊠	4	5	6	* 7 ⊠	* 8 ⊠	* 9
Elm	1	Mean	.80	.60	9.00	1.80	.60	3.60	5.00	7.00	6.
		StDev	.45	.55	1.58	.45	.55	3.21	.71	1.00	.
	2	Mean	1.20	1.00	8.20	1.40	.20	.40	10.00	2.40	3.
		StDev	.45	.00	.45	.55	.45	.55	3.54	2.07	1.
	3	Mean	.80	.40	4.20	1.40	.40	.60	20.00	8.00	6.
		StDev	.84	.55	1.30	.89	.55	.55	11.81	2.55	.
	4	Mean	1.60	.80	4.40	1.20	.60	1.80	13.60	5.80	6.
		StDev	1.14	.45	1.67	.45	.55	.84	3.29	.84	1.
	5	Mean	1.00	.80	4.40	1.80	1.60	5.00	14.20		25.
		StDev	.00	.84	.55	.45	1.14	8.94	2.28		1.
	7	Mean	1.80	3.00	5.80	2.00	1.60	11.40	14.40		12.
		StDev	1.30	3.39	.84	.71	1.95	13.54	6.19		2.
Lan	1	Mean	.80	.20	9.20	1.00	.60	1.80	20.00		
		StDev	.45	.45	1.48	.00	.55	1.30	.00		
	2	Mean	1.00	3.40	7.80	2.40	1.00	.00			
		StDev	.00	3.78	.84	.55	.00	.00			
	3	Mean	6.40	.80	11.40	5.00	4.20				
		StDev	9.84	.84	1.67	6.16	5.07				
	4	Mean						1.60	24.60		
		StDev						.55	1.14		
	5	Mean	1.00	1.00	9.00	5.60	1.60	1.00	14.20	5.00	7.
		StDev	.00	.00	1.22	5.81	1.95	.71	6.26	1.73	4.
	6	Mean	2.00	.40	7.60	1.40	.20			5.00	5.
		StDev	2.24	.55	4.72	.55	.45			1.22	.
	7	Mean	1.40	4.40	8.60	2.60	.00	.60	23.40	5.60	5.
		StDev	1.52	9.84	3.44	1.95	.00	1.34	3.78	1.52	.
MvB	2	Mean	2.60	.20	4.40	2.40	.20	1.20	20.40		
		StDev	3.05	.45	1.14	.55	.45	.45	2.88		
	3	Mean	2.40	1.00	8.60	2.20	8.60			5.40	4.
		StDev	3.13	.71	.89	.45	16.99			.55	.
	4	Mean						1.40	19.40	7.20	6.
		StDev						.55	5.27	1.10	.
	5	Mean	1.00	.60	5.00						
		StDev	.00	1.34	1.00						
	6	Mean				2.60	.80	2.80	18.40		
		StDev				.55	.45	4.60	6.84		
Pns	1	Mean	1.40	.80	13.40	4.20	1.80	.80	27.80	10.00	6.
		StDev	.55	.45	4.93	.84	.45	.45	2.05	8.25	1.
	3	Mean	1.00	.60	11.20	3.40	.80	1.00	12.00	12.20	12.
		StDev	.00	.55	3.27	1.95	.45	.71	1.00	1.92	2.
	4	Mean	1.40	.20							
		StDev	.89	.45							
	5	Mean	1.40	1.20	7.00	2.00	1.20	1.20	18.80	7.60	7.
		StDev	.55	.45	.71	.00	.45	2.17	4.09	.89	.
	6	Mean	.60	.20	7.40	2.00	.40	3.40	12.80	9.40	8.
		StDev	.55	.45	.89	.00	.55	6.50	.45	.55	.
	8	Mean	6.60	.00	5.40	4.80	.60	1.00	26.20	5.60	4.
		StDev	13.65	.00	.55	7.40	.89	.00	4.21	.55	.
	9	Mean		.60	14.00	2.20	.00	1.00	26.80	6.00	6.
		StDev		.55	2.12	.45	.00	.71	1.30	.71	.
	12	Mean	.80	.20	11.80	1.60	.20	.80	20.60	13.20	15.
		StDev	.45	.45	2.39	.55	.45	.45	1.14	4.97	5.
	13	Mean	1.40	2.60	17.40	5.00	.00	2.20	26.00	9.00	7.
		StDev	.89	4.72	5.03	7.84	.00	1.79	3.81	2.83	.
	15	Mean	1.00	.60		1.80	.60	1.00	8.40	8.20	7.
		StDev	.00	.55		.45	.55	.00	.89	1.30	1.
	16	Mean	6.40	.20	16.20	1.60	.40	1.20	14.60	5.80	5.
		StDev	10.99	.45	1.30	.55	.55	.45	5.55	.45	.

Codes by Sample Numbers: * means Lab differences. ⊠ means Tube differences

TABLE 8

FWMA values for T I

Tube No	Stat	Correlation Sample Number * 1 ⊠	* 2 ⊠	* 3 ⊠	* 4 ⊠	* 5 ⊠	* 6 ⊠	* 7 ⊠	* 8 ⊠	* 9 ⊠
1	Mean	6.80	5.20	5.40	9.80	12.00	11.40	9.80	3.60	2.00
	StDev	.45	.45	.55	.84	2.00	3.13	1.10	.89	.00
2	Mean	7.60	5.00	6.40	6.00	7.40	7.00	9.20	2.00	1.00
	StDev	.55	.00	.55	.71	.55	.71	1.10	.00	.00
3	Mean	4.00	2.60	3.40	6.80	11.40	10.00	10.80	3.40	1.00
	StDev	.71	.55	.55	.84	.55	.71	3.56	.55	.00
4	Mean	5.00	2.60	4.00	8.60	12.60	8.60	12.20	2.00	1.00
	StDev	.71	.89	.71	.89	.89	.89	.45	.00	.00
5	Mean	6.00	4.40	4.20	7.00	9.60	8.40	12.20	5.60	1.80
	StDev	1.00	.55	.45	.71	.55	1.34	.45	5.27	1.10
7	Mean	6.60	3.60	4.40	8.80	12.80	7.20	9.80	3.20	1.80
	StDev	.55	.55	.55	1.48	1.48	.45	1.64	.45	.45
1	Mean	7.80	5.20	7.60	11.60	13.80	9.40	15.40		
	StDev	.84	.45	.55	1.14	1.10	.55	.55		
2	Mean	7.20	5.00	6.80	13.40	15.20	8.80			
	StDev	.84	.00	.45	.55	.45	.45			
3	Mean	6.40	4.80	5.80	13.20	15.20				
	StDev	.55	.45	.45	2.17	.84				
4	Mean						9.60	15.80		
	StDev						.55	.45		
5	Mean	7.40	5.00	5.80	13.40	15.00	11.80	18.60	4.40	1.60
	StDev	.55	.00	.45	1.14	1.41	.84	1.95	.55	.89
6	Mean	7.80	5.00	2.80	10.40	11.00	9.40	14.40	2.00	1.00
	StDev	.45	.71	.45	.55	.71	.55	1.95	.71	.00
7	Mean	6.40	4.80	2.00	10.60	11.60	12.20	16.00	1.00	.20
	StDev	.55	.45	.00	.55	.55	1.92	1.58	.00	.45
2	Mean	6.60	4.40	3.20	11.20	13.20	9.20	15.60		
	StDev	.55	1.52	1.64	.84	.84	.45	.89		
3	Mean	6.80	4.60	2.80	11.20	13.40			1.40	1.40
	StDev	.84	.55	.45	4.60	1.82			.55	.55
4	Mean						10.00	16.80	1.20	1.00
	StDev						.00	.84	.45	.00
5	Mean	7.80	7.20	3.40						
	StDev	.84	5.72	.55						
6	Mean				10.40	11.80	9.20	14.40		
	StDev				2.88	1.10	.45	1.14		
1	Mean	5.80	5.20	5.20	9.80	20.60	12.20	16.20	2.80	2.20
	StDev	.45	.45	.45	2.95	1.67	1.30	1.64	.45	.45
3	Mean	7.80	5.80	6.80	12.40	14.80	9.80	16.20	3.20	1.80
	StDev	.45	.45	.45	1.82	1.30	.45	1.30	.45	.45
4	Mean	8.20	7.00	19.60						
	StDev	.45	.00	14.12						
5	Mean	9.20	6.00	7.60	11.00	12.40	11.40	15.20	4.20	2.00
	StDev	.84	.71	.55	.00	.55	.55	4.66	.45	.00
6	Mean	8.20	6.00	7.60	13.20	15.00	10.60	15.40	3.20	1.80
	StDev	.84	.00	.55	.84	1.87	.55	.89	.45	.45
8	Mean	8.80	7.00	7.60	13.00	14.60	11.00	15.40	4.60	2.00
	StDev	.45	.71	.55	1.22	.55	.00	1.82	.55	.00
9	Mean	8.40	6.00	6.40	9.20	13.60	10.40	14.80	3.40	2.00
	StDev	.55	.71	.55	.45	.55	.89	.45	.55	.00
12	Mean	7.60	5.80	6.80	10.60	14.00	8.80	16.20	3.20	1.80
	StDev	.55	.45	.84	.89	1.00	.84	.84	.45	.45
13	Mean	7.60	6.00	6.40	11.40	14.20	10.00	13.00	4.00	2.20
	StDev	.55	.00	2.07	.55	.45	.00	2.00	.00	.45
15	Mean	8.80	6.20	6.40	11.80	14.00	10.40	15.80	3.60	2.00
	StDev	.45	.45	.55	.45	.71	.55	.84	.89	.00
16	Mean	7.40	5.40	5.00	11.20	13.60	11.20	17.60	2.60	1.20
	StDev	.55	.55	.00	.84	.55	.45	1.14	.55	.45

des by Sample Numbers: * means Lab differences. ⊠ means Tube differences

TABLE 9

Analyses of Variance Correlation Sample Data for FWMA
For Element: FE

Correlation Sample 1

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	138.62	46.21	60.4*
Tubes/Instrs	22	311.90	14.18	18.5*
Residual	104	79.60	.77	

Correlation Sample 2

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	1917.66	639.22	156.6*
Tubes/Instrs	22	1109.91	50.45	12.4*
Residual	104	424.40	4.08	

Correlation Sample 3

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	406.76	135.59	38.4*
Tubes/Instrs	22	492.41	22.38	6.3*
Residual	104	366.80	3.53	

Correlation Sample 4

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	219.16	73.05	63.9*
Tubes/Instrs	21	176.25	8.39	7.3*
Residual	100	114.40	1.14	

Correlation Sample 5

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	662.14	220.71	34.3*
Tubes/Instrs	21	1364.39	64.97	10.1*
Residual	100	644.00	6.44	

Correlation Sample 6

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	14.92	4.97	10.8*
Tubes/Instrs	21	123.69	5.89	12.8*
Residual	100	46.00	.46	

Correlation Sample 7

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	23461.52	7820.51	106.1*
Tubes/Instrs	20	8892.48	444.62	6.0*
Residual	96	7079.20	73.74	

Correlation Sample 8

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	152.68	50.89	18.8*
Tubes/Instrs	17	220.88	12.99	4.8*
Residual	84	227.20	2.70	

Correlation Sample 9

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	2171.11	723.70	134.5*
Tubes/Instrs	17	9227.12	542.77	100.9*
Residual	84	452.00	5.38	

Table 10

Analyses of Variance Correlation Sample Data for FWMA
For Element: AG

Correlation Sample 1

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	152.94	50.98	98.9*
Tubes/Instrs	22	283.99	12.91	25.0*
Residual	104	53.60	.52	

Correlation Sample 2

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	130.36	43.45	56.8*
Tubes/Instrs	22	158.27	7.19	9.4*
Residual	104	79.60	.77	

Correlation Sample 3

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	94.46	31.49	15.0*
Tubes/Instrs	22	318.04	14.46	6.9*
Residual	104	218.40	2.10	

Correlation Sample 4

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	469.67	156.56	240.1*
Tubes/Instrs	21	425.50	20.26	31.1*
Residual	100	65.20	.65	

Correlation Sample 5

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	137.65	45.88	254.9*
Tubes/Instrs	21	201.55	9.60	53.3*
Residual	100	18.00	.18	

Correlation Sample 6

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	28.79	9.60	10.1*
Tubes/Instrs	21	114.78	5.47	5.8*
Residual	100	94.80	.95	

Correlation Sample 7

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	.05	.02	.5
Tubes/Instrs	20	.72	.04	1.1
Residual	96	3.20	.03	

Correlation Sample 8

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	.00	.00	1.0
Tubes/Instrs	17	.00	.00	1.0
Residual	84	.00	.00	

Correlation Sample 9

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	.00	.00	1.0
Tubes/Instrs	17	.00	.00	1.0
Residual	84	.00	.00	

Table 11

Analyses of Variance Correlation Sample Data for FWMA
For Element: AL

Correlation Sample 1

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	716.19	238.73	11.4*
Tubes/Instrs	22	2182.31	99.20	4.7*
Residual	104	2180.00	20.96	

Correlation Sample 2

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	485.14	161.71	9.9*
Tubes/Instrs	22	600.59	27.30	1.7
Residual	104	1694.80	16.30	

Correlation Sample 3

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	442.89	147.63	17.4*
Tubes/Instrs	21	698.99	33.29	3.9*
Residual	100	848.40	8.48	

Correlation Sample 4

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	683.21	227.74	21.3*
Tubes/Instrs	21	782.35	37.25	3.5*
Residual	100	1067.20	10.67	

Correlation Sample 5

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	69.78	23.26	3.3
Tubes/Instrs	21	415.45	19.78	2.8*
Residual	100	714.80	7.15	

Correlation Sample 6

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	45.45	15.15	.7
Tubes/Instrs	21	1243.07	59.19	2.8*
Residual	100	2126.80	21.27	

Correlation Sample 7

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	2662.31	887.44	43.4*
Tubes/Instrs	20	2253.79	112.69	5.5*
Residual	96	1961.60	20.43	

Correlation Sample 8

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	1069.23	356.41	14.9*
Tubes/Instrs	16	2801.01	175.06	7.3*
Residual	80	1912.40	23.90	

Correlation Sample 9

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	877.43	292.48	14.1*
Tubes/Instrs	16	988.76	61.80	3.0*
Residual	80	1663.60	20.79	

Table 12

Analyses of Variance Correlation Sample Data for FWMA
For Element: CR

Correlation Sample 1

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	83.83	27.94	27.4*
Tubes/Instrs	22	123.40	5.61	5.5*
Residual	104	106.00	1.02	

Correlation Sample 2

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	152.30	50.77	54.8*
Tubes/Instrs	22	136.81	6.22	6.7*
Residual	104	96.40	.93	

Correlation Sample 3

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	23.98	7.99	77.0*
Tubes/Instrs	22	15.69	.71	6.9*
Residual	104	10.80	.10	

Correlation Sample 4

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	595.23	198.41	384.5*
Tubes/Instrs	21	139.45	6.64	12.9*
Residual	100	51.60	.52	

Correlation Sample 5

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	72.43	24.14	49.5*
Tubes/Instrs	21	130.48	6.21	12.7*
Residual	100	48.80	.49	

Correlation Sample 6

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	24.44	8.15	6.7*
Tubes/Instrs	21	43.05	2.05	1.7
Residual	100	121.20	1.21	

Correlation Sample 7

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	18.42	6.14	44.7*
Tubes/Instrs	20	21.18	1.06	7.7*
Residual	96	13.20	.14	

Correlation Sample 8

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	30.89	10.30	63.6*
Tubes/Instrs	17	18.50	1.09	6.7*
Residual	84	13.60	.16	

Correlation Sample 9

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	15.43	5.14	51.4*
Tubes/Instrs	17	26.80	1.58	15.8*
Residual	84	8.40	.10	

Table 13

Analyses of Variance Correlation Sample Data for PWMA
For Element: CU

Correlation Sample 1

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	1259.86	419.95	49.4*
Tubes/Instrs	21	3595.37	171.21	20.1*
Residual	100	850.00	8.50	

Correlation Sample 2

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	167.08	55.69	71.3*
Tubes/Instrs	22	183.15	8.32	10.7*
Residual	104	81.20	.78	

Correlation Sample 3

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	2539.80	846.60	29.7*
Tubes/Instrs	22	6672.50	303.30	10.6*
Residual	104	2968.00	28.54	

Correlation Sample 4

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	330.01	110.00	53.4*
Tubes/Instrs	21	224.75	10.70	5.2*
Residual	100	206.00	2.06	

Correlation Sample 5

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	69.76	23.25	.9
Tubes/Instrs	21	398.35	18.97	.7
Residual	100	2618.80	26.19	

Correlation Sample 6

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	65.40	21.80	8.1*
Tubes/Instrs	21	199.40	9.50	3.5*
Residual	100	269.20	2.69	

Correlation Sample 7

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	4821.14	1607.05	44.4*
Tubes/Instrs	20	3078.65	153.93	4.3*
Residual	96	3471.20	36.16	

Correlation Sample 8

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	4314.87	1438.29	92.6*
Tubes/Instrs	16	3703.24	231.45	14.9*
Residual	80	1243.20	15.54	

Correlation Sample 9

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	3482.35	1160.78	184.4*
Tubes/Instrs	17	13006.99	765.12	121.5*
Residual	84	528.80	6.30	

Table 14

Analyses of Variance Correlation Sample Data for PWMA
For Element: MG

Correlation Sample 1

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	114.76	38.25	42.3*
Tubes/Instrs	22	136.81	6.22	6.9*
Residual	104	94.00	.90	

Correlation Sample 2

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	1324.92	441.64	92.8*
Tubes/Instrs	22	334.81	15.22	3.2*
Residual	104	495.20	4.76	

Correlation Sample 3

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	494.26	164.75	16.6*
Tubes/Instrs	22	1226.36	55.74	5.6*
Residual	104	1032.80	9.93	

Correlation Sample 4

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	1333.83	444.61	90.1*
Tubes/Instrs	21	220.45	10.50	2.1*
Residual	100	493.20	4.93	

Correlation Sample 5

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	494.89	164.96	103.6*
Tubes/Instrs	21	1279.07	60.91	38.3*
Residual	100	159.20	1.59	

Correlation Sample 6

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	7.01	2.34	7.0*
Tubes/Instrs	21	20.59	.98	3.0*
Residual	100	33.20	.33	

Correlation Sample 7

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	1490.04	496.68	71.0*
Tubes/Instrs	20	898.55	44.93	6.4*
Residual	96	672.00	7.00	

Correlation Sample 8

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	242.27	80.76	20.4*
Tubes/Instrs	17	2264.59	133.21	33.6*
Residual	84	333.20	3.97	

Correlation Sample 9

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	79.33	26.44	17.6*
Tubes/Instrs	17	654.12	38.48	25.6*
Residual	84	126.40	1.50	

Table 15

Analyses of Variance Correlation Sample Data for FWMA
For Element: NI

Correlation Sample 1

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	86.50	28.83	187.4*
Tubes/Instrs	22	70.60	3.21	20.9*
Residual	104	16.00	.15	

Correlation Sample 2

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	269.89	89.96	168.3*
Tubes/Instrs	22	181.71	8.26	15.4*
Residual	104	55.60	.53	

Correlation Sample 3

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	1498.20	499.40	88.4*
Tubes/Instrs	22	957.77	43.53	7.7*
Residual	104	587.60	5.65	

Correlation Sample 4

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	266.67	88.89	300.3*
Tubes/Instrs	21	125.29	5.97	20.2*
Residual	100	29.60	.30	

Correlation Sample 5

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	13.39	4.46	123.9*
Tubes/Instrs	21	30.65	1.46	40.5*
Residual	100	3.60	.04	

Correlation Sample 6

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	88.46	29.49	37.6*
Tubes/Instrs	21	134.93	6.43	8.2*
Residual	100	78.40	.78	

Correlation Sample 7

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	762.48	254.16	209.6*
Tubes/Instrs	20	73.92	3.70	3.0*
Residual	96	116.40	1.21	

Correlation Sample 8

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	52.34	17.45	18.2*
Tubes/Instrs	17	88.82	5.22	5.5*
Residual	84	80.40	.96	

Correlation Sample 9

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	86.44	28.81	106.2*
Tubes/Instrs	17	586.72	34.51	127.2*
Residual	84	22.80	.27	

Table 16

Analyses of Variance Correlation Sample Data for PWMA
For Element: SI

Correlation Sample 1

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	20.53	6.84	.4
Tubes/Instrs	21	362.30	17.25	1.0
Residual	100	1749.20	17.49	

Correlation Sample 2

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	23.96	7.99	1.4
Tubes/Instrs	22	128.24	5.83	1.0
Residual	104	608.80	5.85	

Correlation Sample 3

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	478.08	159.36	.7
Tubes/Instrs	22	22211.65	1009.62	4.1*
Residual	104	25335.20	243.61	

Correlation Sample 4

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	38.27	12.76	1.6
Tubes/Instrs	21	175.22	8.34	1.0
Residual	100	803.60	8.04	

Correlation Sample 5

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	81.52	27.17	2.1
Tubes/Instrs	21	302.83	14.42	1.1
Residual	100	1311.60	13.12	

Correlation Sample 6

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	146.62	48.87	3.3
Tubes/Instrs	20	476.50	23.83	1.6
Residual	96	1413.20	14.72	

Correlation Sample 7

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	1136.21	378.74	20.9*
Tubes/Instrs	19	3132.44	164.87	9.1*
Residual	92	1666.40	18.11	

Correlation Sample 8

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	1550.80	516.93	2.3
Tubes/Instrs	17	2704.77	159.10	.7
Residual	84	19151.20	227.99	

Correlation Sample 9

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	281.68	93.89	25.9*
Tubes/Instrs	17	2145.71	126.22	34.9*
Residual	84	304.00	3.62	

Table 17

Analyses of Variance Correlation Sample Data for PWMA
For Element: TI

Correlation Sample 1

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	77.00	25.67	63.0*
Tubes/Instrs	22	99.68	4.53	11.1*
Residual	104	42.40	.41	

Correlation Sample 2

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	91.34	30.45	19.4*
Tubes/Instrs	22	73.59	3.35	2.1*
Residual	104	163.60	1.57	

Correlation Sample 3

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	371.61	123.87	15.2*
Tubes/Instrs	22	964.49	43.84	5.4*
Residual	104	849.60	8.17	

Correlation Sample 4

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	327.48	109.16	45.3*
Tubes/Instrs	21	180.52	8.60	3.6*
Residual	100	240.80	2.41	

Correlation Sample 5

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	265.62	88.54	76.6*
Tubes/Instrs	21	425.61	20.27	17.5*
Residual	100	115.60	1.16	

Correlation Sample 6

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	53.01	17.67	18.4*
Tubes/Instrs	21	175.12	8.34	8.7*
Residual	100	96.00	.96	

Correlation Sample 7

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	537.56	179.19	58.0*
Tubes/Instrs	20	156.83	7.84	2.5*
Residual	96	296.40	3.09	

Correlation Sample 8

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	46.78	15.59	9.9*
Tubes/Instrs	17	92.21	5.42	3.4*
Residual	84	132.40	1.58	

Correlation Sample 9

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	13.45	4.48	24.1*
Tubes/Instrs	17	14.80	.87	4.7*
Residual	84	15.60	.19	

Table 18

Dash-3 Values for Element FE

ple ber	Stat	Base			
		Elmendorf	Langley	Myrtle Beach	NARF Pensacola
*	Mean	16.17	15.67	14.50	13.50
	StDev	.41	2.07	.58	.85
	Size	6	6	4	10
	Mean	56.17	52.50	49.00	44.40
	StDev	3.25	7.40	.00	9.36
	Size	6	6	4	10
*	Mean	13.83	11.57	8.00	11.00
	StDev	.75	3.55	.00	.82
	Size	6	7	5	10
	Mean	16.17	14.33	16.00	14.86
	StDev	.41	1.63	1.00	1.57
	Size	6	6	3	7
*	Mean	47.83	38.33	46.67	41.43
	StDev	2.23	4.68	.58	3.15
	Size	6	6	3	7
	Mean	7.67	6.00	7.60	6.90
	StDev	.52	1.41	.55	.74
	Size	6	4	5	10
*	Mean	123.83	101.75	124.67	116.20
	StDev	2.14	15.67	5.16	12.13
	Size	6	4	6	10
*	Mean	10.33	4.67	3.00	8.50
	StDev	.52	3.79	.00	1.31
	Size	6	3	3	8
*	Mean	63.17	45.00	44.00	52.00
	StDev	.98	10.82	.00	4.66
	Size	6	3	3	8

by the sample number indicates significant Base difference. α=.01

TABLE 19

Dash-3 Values for Element **AG**

Sample Number	Stat	Base Elmendorf	 Langley	 Myrtle Beach	 NARF Pensacola
1*	Mean	8.67	9.67	10.00	7.20
	StDev	.52	1.21	.00	.79
	Size	6	6	4	10
2*	Mean	21.83	22.00	21.00	15.80
	StDev	1.60	2.53	.00	3.08
	Size	6	6	4	10
3*	Mean	21.17	24.57	23.00	18.90
	StDev	2.04	5.03	.00	1.52
	Size	6	7	5	10
4*	Mean	14.50	14.83	16.67	12.71
	StDev	.55	1.17	.58	.76
	Size	6	6	3	7
5	Mean	8.83	6.83	9.00	7.29
	StDev	.41	2.64	.00	.76
	Size	6	6	3	7
6*	Mean	17.17	15.50	17.00	14.20
	StDev	.98	1.73	1.00	.92
	Size	6	4	5	10
7*	Mean	.00	1.00	.33	.00
	StDev	.00	.00	.82	.00
	Size	6	4	6	10
8	Mean	.00	1.00	.00	.00
	StDev	.00	.00	.00	.00
	Size	6	3	3	8
9	Mean	.00	1.00	.00	.00
	StDev	.00	.00	.00	.00
	Size	6	3	3	8

* by the sample number indicates significant Base difference. α=.01

TABLE 20

Dash-3 Values for Element AL

le er	Stat	Base Elmendorf	 Langley	 Myrtle Beach	 NARF Pensacola
	Mean	32.17	27.50	29.75	27.60
	StDev	.75	1.05	.50	3.69
	Size	6	6	4	10
	Mean	14.00	10.00	11.00	12.40
	StDev	.00	.89	.00	8.77
	Size	6	6	4	10
	Mean	14.83	11.57	10.00	10.00
	StDev	.98	2.76	.00	1.49
	Size	6	7	5	10
	Mean	20.67	18.33	16.67	16.71
	StDev	.82	3.72	.58	1.11
	Size	6	6	3	7
	Mean	5.67	3.17	2.00	2.57
	StDev	.52	2.14	.00	1.40
	Size	6	6	3	7
	Mean	21.33	15.25	15.40	16.20
	StDev	.52	4.35	1.14	1.23
	Size	6	4	5	10
	Mean	40.33	32.25	36.50	36.90
	StDev	1.03	7.59	1.38	5.17
	Size	6	4	6	10
	Mean	52.50	43.67	47.00	52.13
	StDev	1.64	14.47	.00	3.18
	Size	6	3	3	8
	Mean	26.83	19.67	21.00	23.88
	StDev	.98	5.51	.00	2.85
	Size	6	3	3	8

by the sample number indicates significant Base difference. α=.01

TABLE 21

Dash-3 Values for Element CR

Sample Number	Stat	Base			
		Elmendorf	Langley	Myrtle Beach	NARF Pensacola
1	Mean	10.33	10.67	10.00	9.90
	StDev	.52	1.21	.00	.32
	Size	6	6	4	10
2*	Mean	11.83	12.83	11.00	12.00
	StDev	.75	.98	.00	.47
	Size	6	6	4	10
3*	Mean	2.17	2.43	1.00	2.40
	StDev	.41	.53	.00	.52
	Size	6	7	5	10
4	Mean	12.83	12.83	11.67	12.57
	StDev	.75	.75	.58	.98
	Size	6	6	3	7
5*	Mean	13.33	12.00	11.67	12.71
	StDev	.52	1.10	.58	.49
	Size	6	6	3	7
6	Mean	6.00	6.25	6.00	6.20
	StDev	.00	.96	1.73	.42
	Size	6	4	5	10
7	Mean	3.00	3.25	3.00	3.50
	StDev	.00	.50	.00	.53
	Size	6	4	6	10
8	Mean	2.00	1.33	1.33	2.13
	StDev	.00	.58	2.31	.35
	Size	6	3	3	8
9*	Mean	2.00	1.33	.00	2.13
	StDev	.00	.58	.00	.35
	Size	6	3	3	8

* by the sample number indicates significant Base difference. $\alpha=.01$

TABLE 22

Dash-3 Values for Element **CU**

ple ber	Stat	Base			
		Elmendorf	Langley	Myrtle Beach	NARF Pensacola
	Mean	38.83	42.17	39.75	37.80
	StDev	.75	7.73	.50	1.99
	Size	6	6	4	10
	Mean	16.17	17.50	16.00	19.50
	StDev	.98	2.51	.00	11.09
	Size	6	6	4	10
	Mean	64.50	65.29	54.00	63.00
	StDev	1.22	13.09	.00	3.89
	Size	6	7	5	10
	Mean	15.00	14.67	15.00	14.86
	StDev	.89	1.63	.00	1.21
	Size	6	6	3	7
	Mean	10.00	8.83	9.67	9.71
	StDev	.00	.98	.58	.49
	Size	6	6	3	7
	Mean	20.17	19.50	19.60	19.10
	StDev	.41	1.73	.55	.88
	Size	6	4	5	10
	Mean	67.83	65.00	66.67	66.60
	StDev	1.83	6.38	4.27	3.53
	Size	6	4	6	10
	Mean	51.33	40.67	34.00	50.00
*	StDev	1.63	6.03	.00	3.38
	Size	6	3	3	8
	Mean	53.17	39.33	36.67	48.50
*	StDev	.98	4.51	.58	2.39
	Size	6	3	3	8

by the sample number indicates significant Base difference, α=.01

TABLE 23

Dash-3 Values for Element **MG**

Sample Number	Stat	Base			
		Elmendorf	Langley	Myrtle Beach	NARF Pensacola
1*	Mean	13.33	13.00	13.00	10.50
	StDev	.52	1.10	.00	.85
	Size	6	6	4	10
2*	Mean	23.67	23.33	23.50	19.80
	StDev	.52	2.58	.58	1.75
	Size	6	6	4	10
3*	Mean	40.33	40.43	40.00	34.30
	StDev	1.21	6.29	.00	2.98
	Size	6	7	5	10
4	Mean	17.83	16.67	18.67	14.86
	StDev	.75	4.68	2.08	1.57
	Size	6	6	3	7
5	Mean	47.33	46.00	48.00	39.86
	StDev	1.37	9.08	.00	4.22
	Size	6	6	3	7
6	Mean	4.17	4.25	3.80	3.50
	StDev	.41	.96	.45	1.08
	Size	6	4	5	10
7	Mean	32.00	25.50	34.00	27.90
	StDev	.89	16.52	2.97	2.73
	Size	6	4	6	10
8	Mean	54.67	34.67	57.33	50.88
	StDev	2.42	35.00	.58	5.30
	Size	6	3	3	8
9	Mean	48.83	50.33	48.33	41.25
	StDev	1.33	13.01	.58	4.98
	Size	6	3	3	8

* by the sample number indicates significant Base difference. α=.01

TABLE 24

Dash-3 Values for Element NI

le er	Stat	Base Elmendorf	 Langley	 Myrtle Beach	 NARF Pensacola
	Mean	11.00	11.17	10.00	10.20
	StDev	.00	2.48	.00	.42
	Size	6	6	4	10
	Mean	18.17	19.33	17.00	16.90
	StDev	.41	3.14	.00	1.52
	Size	6	6	4	10
	Mean	53.00	54.57	48.00	50.40
	StDev	1.10	10.11	.00	2.12
	Size	6	7	5	10
	Mean	13.17	12.50	13.67	12.57
	StDev	.75	1.05	.58	.79
	Size	6	6	3	7
	Mean	5.83	4.67	5.33	4.86
*	StDev	.41	.52	.58	.38
	Size	6	6	3	7
	Mean	24.50	23.25	16.40	22.10
	StDev	.55	1.71	10.41	.88
	Size	6	4	5	10
	Mean	24.50	23.25	24.83	22.90
	StDev	.55	2.63	.75	.99
	Size	6	4	6	10
	Mean	8.67	7.33	7.00	7.88
	StDev	.52	1.15	.00	.83
	Size	6	3	3	8
	Mean	17.67	14.00	12.00	15.88
*	StDev	.82	2.00	.00	.83
	Size	6	3	3	8

by the sample number indicates significant Base difference, $\alpha=.01$

TABLE 25

Dash-3 Values for Element SI

Sample Number	Stat	Base			
		Elmendorf	Langley	Myrtle Beach	NARF Pensacola
1	Mean StDev Size	10.50 1.64 6	8.00 1.10 6	8.00 .00 4	8.90 3.41 10
2	Mean StDev Size	5.17 .98 6	5.67 .82 6	4.50 .58 4	5.40 2.80 10
3	Mean StDev Size	23.00 1.26 6	22.00 3.51 7	21.80 .45 5	19.50 3.14 10
4*	Mean StDev Size	18.33 1.37 6	16.00 2.28 6	20.33 .58 3	15.57 .98 7
5	Mean StDev Size	5.83 .75 6	3.50 1.05 6	5.67 .58 3	7.14 11.85 7
6	Mean StDev Size	5.67 1.51 6	4.50 1.73 4	5.60 .89 5	4.40 3.10 10
7	Mean StDev Size	58.50 1.52 6	54.50 12.66 4	64.67 3.20 6	53.70 6.34 10
8	Mean StDev Size	31.67 1.51 6	27.33 7.02 3	32.33 .58 3	29.75 2.76 8
9	Mean StDev Size	32.67 1.51 6	29.67 5.51 3	32.00 .00 3	28.13 4.52 8

* by the sample number indicates significant Base difference, α=.01

TABLE 26

Dash-3 Values for Element TI

le		Base			
er	Stat	Elmendorf	Langley	Myrtle Beach	NARF Pensacola
	Mean	14.17	14.50	13.25	12.40
	StDev	.41	3.02	.50	1.07
	Size	6	6	4	10
	Mean	9.00	9.17	9.00	8.60
	StDev	.63	2.56	.00	2.37
	Size	6	6	4	10
	Mean	10.50	9.00	5.00	8.50
-	StDev	.84	3.00	.00	.85
	Size	6	7	5	10
	Mean	17.67	17.50	17.00	15.86
	StDev	.82	2.81	1.00	1.21
	Size	6	6	3	7
	Mean	20.17	18.83	19.67	17.00
	StDev	.98	3.06	.58	1.29
	Size	6	6	3	7
	Mean	16.67	16.25	17.60	15.30
	StDev	.52	2.50	1.82	1.89
	Size	6	4	5	10
	Mean	26.00	26.00	26.00	24.70
	StDev	.63	3.37	.63	2.00
	Size	6	4	6	10
	Mean	6.67	3.00	2.00	6.25
	StDev	.52	2.00	.00	1.58
	Size	6	3	3	8
	Mean	3.83	1.67	2.00	3.38
	StDev	.41	1.53	.00	1.30
	Size	6	3	3	8

by the sample number indicates significant Base difference, α=.01

TABLE 27

Analyses of Variance Correlation Sample Data for Dash-3
For Element: FE

Correlation Sample 1

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	32.95	10.98	8.1*
Residual	22	29.67	1.35	

Correlation Sample 2

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	580.81	193.60	3.8
Residual	22	1114.73	50.67	

Correlation Sample 3

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	94.17	31.39	8.9*
Residual	24	84.55	3.52	

Correlation Sample 4

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	12.84	4.28	2.5
Residual	18	31.02	1.72	

Correlation Sample 5

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	328.41	109.47	10.1*
Residual	18	194.55	10.81	

Correlation Sample 6

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	8.41	2.80	4.4
Residual	21	13.43	.64	

Correlation Sample 7

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	1557.02	519.01	5.2*
Residual	22	2216.52	100.75	

Correlation Sample 8

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	140.55	46.85	17.8*
Residual	16	42.00	2.62	

Correlation Sample 9

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	1062.97	354.32	14.5*
Residual	16	390.83	24.43	

Table 28

Analyses of Variance Correlation Sample Data for Dash-3
For Element: AG

Correlation Sample 1

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	34.19	11.40	17.6*
Residual	22	14.27	.65	

Correlation Sample 2

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	215.91	71.97	12.1*
Residual	22	130.43	5.93	

Correlation Sample 3

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	145.52	48.51	6.0*
Residual	24	193.45	8.06	

Correlation Sample 4

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	36.34	12.11	17.5*
Residual	18	12.43	.69	

Correlation Sample 5

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	18.18	6.06	2.8
Residual	18	39.10	2.17	

Correlation Sample 6

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	44.01	14.67	12.1*
Residual	21	25.43	1.21	

Correlation Sample 7

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	3.28	1.09	7.2*
Residual	22	3.33	.15	

Correlation Sample 8

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	2.55	.85	NO TEST
Residual	16	.00	.00	

Correlation Sample 9

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	2.55	.85	NO TEST
Residual	16	.00	.00	

Table 29

Analyses of Variance Correlation Sample Data for Dash-3
For Element: AL

Correlation Sample 1

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	95.48	31.83	5.3*
Residual	22	131.48	5.98	

Correlation Sample 2

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	53.60	17.87	.6
Residual	22	696.40	31.65	

Correlation Sample 3

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	100.31	33.44	11.4*
Residual	24	70.55	2.94	

Correlation Sample 4

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	59.10	19.70	4.4
Residual	18	80.76	4.49	

Correlation Sample 5

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	41.62	13.87	7.0*
Residual	18	35.88	1.99	

Correlation Sample 6

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	143.76	47.92	13.1*
Residual	21	76.88	3.66	

Correlation Sample 7

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	158.17	52.72	2.7
Residual	22	428.48	19.48	

Correlation Sample 8

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	220.16	73.39	2.3
Residual	16	503.04	31.44	

Correlation Sample 9

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	129.83	43.28	5.7*
Residual	16	122.37	7.65	

Table 30

Analyses of Variance Correlation Sample Data for Dash-3
For Element: CR

Correlation Sample 1

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	2.47	.82	1.9
Residual	22	9.57	.43	

Correlation Sample 2

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	8.33	2.78	6.3*
Residual	22	9.67	.44	

Correlation Sample 3

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	7.73	2.58	12.5*
Residual	24	4.95	.21	

Correlation Sample 4

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	3.27	1.09	1.6
Residual	18	12.05	.67	

Correlation Sample 5

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	8.03	2.68	5.1*
Residual	18	9.43	.52	

Correlation Sample 6

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	.29	.10	.1
Residual	21	16.35	.78	

Correlation Sample 7

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	1.37	.46	3.1
Residual	22	3.25	.15	

Correlation Sample 8

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	2.34	.78	1.0
Residual	16	12.21	.76	

Correlation Sample 9

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	11.01	3.67	38.1*
Residual	16	1.54	.10	

Table 31

Analyses of Variance Correlation Sample Data for Dash-3
For Element: CU

		Correlation Sample 1		
Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	73.87	24.62	1.6
Residual	22	338.02	15.36	

		Correlation Sample 2		
Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	58.28	19.43	.4
Residual	22	1142.83	51.95	

		Correlation Sample 3		
Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	440.79	146.93	3.0
Residual	24	1170.93	48.79	

		Correlation Sample 4		
Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	.40	.13	.1
Residual	18	26.19	1.46	

		Correlation Sample 5		
Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	4.53	1.51	3.9
Residual	18	6.93	.38	

		Correlation Sample 6		
Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	4.31	1.44	1.7
Residual	21	17.93	.85	

		Correlation Sample 7		
Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	19.32	6.44	.4
Residual	22	342.57	15.57	

		Correlation Sample 8		
Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	808.80	269.60	26.0*
Residual	16	166.00	10.37	

		Correlation Sample 9		
Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	741.58	247.19	45.9*
Residual	16	86.17	5.39	

Table 32

Analyses of Variance Correlation Sample Data for Dash-3
For Element: MG

Correlation Sample 1

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	42.82	14.27	22.7*
Residual	22	13.83	.63	

Correlation Sample 2

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	84.58	28.19	9.8*
Residual	22	63.27	2.88	

Correlation Sample 3

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	230.28	76.76	5.7*
Residual	24	325.15	13.55	

Correlation Sample 4

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	43.08	14.36	1.9
Residual	18	135.69	7.54	

Correlation Sample 5

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	248.58	82.86	2.8
Residual	18	528.19	29.34	

Correlation Sample 6

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	2.48	.83	1.2
Residual	21	14.88	.71	

Correlation Sample 7

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	244.75	81.58	1.9
Residual	22	933.90	42.45	

Correlation Sample 8

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	997.41	332.47	2.0
Residual	16	2677.54	167.35	

Correlation Sample 9

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	301.28	100.43	3.1
Residual	16	521.67	32.60	

Table 33

Analyses of Variance Correlation Sample Data for Dash-3
For Element: NI

Correlation Sample 1

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	5.91	1.97	1.3
Residual	22	32.43	1.47	

Correlation Sample 2

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	25.55	8.52	2.6
Residual	22	71.07	3.23	

Correlation Sample 3

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	152.74	50.91	1.9
Residual	24	660.11	27.50	

Correlation Sample 4

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	3.88	1.29	1.8
Residual	18	12.71	.71	

Correlation Sample 5

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	4.90	1.63	8.0*
Residual	18	3.69	.21	

Correlation Sample 6

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	198.69	66.23	3.1
Residual	21	450.35	21.45	

Correlation Sample 7

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	18.63	6.21	4.0
Residual	22	33.98	1.54	

Correlation Sample 8

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	6.93	2.31	4.2
Residual	16	8.87	.55	

Correlation Sample 9

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	72.74	24.25	23.9*
Residual	16	16.21	1.01	

Table 34

Analyses of Variance Correlation Sample Data for Dash-3
For Element: SI

Correlation Sample 1

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	23.45	7.82	1.4
Residual	22	124.40	5.65	

Correlation Sample 2

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	3.55	1.18	.3
Residual	22	79.57	3.62	

Correlation Sample 3

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	54.41	18.14	2.5
Residual	24	171.30	7.14	

Correlation Sample 4

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	64.10	21.37	9.2*
Residual	18	41.71	2.32	

Correlation Sample 5

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	43.46	14.49	.3
Residual	18	851.86	47.33	

Correlation Sample 6

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	9.03	3.01	.6
Residual	21	109.93	5.23	

Correlation Sample 7

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	494.53	164.84	4.0
Residual	22	905.93	41.18	

Correlation Sample 8

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	52.38	17.46	1.7
Residual	16	164.17	10.26	

Correlation Sample 9

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	81.33	27.11	2.0
Residual	16	214.87	13.43	

Table 35

Analyses of Variance Correlation Sample Data for Dash-3
For Element: TI

Correlation Sample 1

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	20.86	6.95	2.7
Residual	22	57.48	2.61	

Correlation Sample 2

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	1.42	.47	.1
Residual	22	85.23	3.87	

Correlation Sample 3

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	86.86	28.95	10.9*
Residual	24	64.00	2.67	

Correlation Sample 4

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	13.26	4.42	1.5
Residual	18	53.69	2.98	

Correlation Sample 5

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	36.03	12.01	3.5
Residual	18	62.33	3.46	

Correlation Sample 6

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	19.18	6.39	2.1
Residual	21	65.38	3.11	

Correlation Sample 7

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	10.40	3.47	1.0
Residual	22	74.10	3.37	

Correlation Sample 8

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	66.92	22.31	13.3*
Residual	16	26.83	1.68	

Correlation Sample 9

Source	DF	Sums of Squares	Mean Squares	F
Instruments	3	13.58	4.53	4.2
Residual	16	17.37	1.09	

Table 36

Verification Sample Data for PWMA Analyses of Variance

For Element **Fe**

Source	DF	SS	MS	F
Instrument		2220.223	370.037	14.52*
Tubes/Inst		5607.089	112.142	4.40*
Days/Tubes		9143.548	72.568	2.85*
Early-Late		8874.806	60.786	2.38*
Residual		4205.667	25.489	

For Element **Ag**

Source	DF	SS	MS	F
Instrument	6	41.472	6.912	15.24*
Tubes/Inst	50	146.576	2.932	6.46*
Days/Tubes	126	101.310	.804	1.77*
Early-Late	146	96.597	.662	1.46*
Residual	165	74.833	.454	

For Element **Al**

Source	DF	SS	MS	F
Instrument	6	800.830	133.472	11.80*
Tubes/Inst	50	1226.932	24.539	2.17*
Days/Tubes	126	2795.636	22.188	1.96*
Early-Late	146	2176.667	14.909	1.32
Residual	165	1866.000	11.309	

For Element **Cr**

Source	DF	SS	MS	F
Instrument	6	14.163	2.361	9.09*
Tubes/Inst	50	53.855	1.077	4.15*
Days/Tubes	126	112.849	.896	3.45*
Early-Late	146	71.278	.488	1.88*
Residual	165	42.833	.260	

For Element **Cu**

Source	DF	SS	MS	F
Instrument	6	48.728	8.121	2.15
Tubes/Inst	50	1354.869	27.097	7.16*
Days/Tubes	126	1654.450	13.131	3.47*
Early-Late	146	1667.375	11.420	3.02*
Residual	165	624.667	3.786	

For Element **Mg**

Source	DF	SS	MS	F
Instrument	6	1384.444	230.741	76.27*
Tubes/Inst	50	513.515	10.270	3.39*
Days/Tubes	126	1390.036	11.032	3.65*
Early-Late	146	1063.833	7.287	2.41*
Residual	165	499.167	3.025	

Table 37

Table 39 Correlation Samples Summary
Overall Standard Deviations

			Sample Number							
El	Inst	Stat	1	2	3	4	5	6	7	8
Fe	Dash-3	Mean	14.8	49.7	11.2	15.2	43.0	7.1	117.7	7.6
		StDev	1.6	8.2	2.6	1.4	5.0	1.0	12.3	3.1
		Size	26	26	28	22	22	25	26	20
	FWMA	Mean	9.6	26.0	7.0	7.3	19.6	4.0	65.3	4.6
		StDev	2.0	5.2	3.1	2.0	4.6	1.2	18.4	2.4
		Size	130	130	130	125	125	125	120	105
Ag	Dash-3	Mean	8.5	19.4	21.5	14.3	7.8	15.7	.2	.2
		StDev	1.4	3.7	3.5	1.5	1.7	1.7	.5	.4
		Size	26	26	28	22	22	25	26	20
	FWMA	Mean	5.6	10.9	12.1	8.6	3.7	9.3	.0	.0
		StDev	2.0	1.7	2.2	2.8	1.7	1.4	.0	.0
		Size	130	130	130	125	125	125	120	105
Al	Dash-3	Mean	29.0	12.0	11.4	18.2	3.5	17.1	36.9	50.2
		StDev	3.0	5.5	2.5	2.6	1.9	3.0	4.8	6.2
		Size	26	26	28	22	22	25	26	20
	FWMA	Mean	14.5	8.2	9.2	10.2	4.1	11.7	21.7	24.4
		StDev	6.3	4.6	4.0	4.5	3.1	5.3	7.6	7.6
		Size	130	130	130	125	125	125	120	105
Cr	Dash-3	Mean	10.2	12.0	2.1	12.6	12.5	6.1	3.2	1.9
		StDev	.7	.8	.7	.9	.9	.8	.4	.9
		Size	26	26	28	22	22	25	26	20
	FWMA	Mean	6.9	7.9	1.7	8.8	10.0	4.8	2.1	1.3
		StDev	1.6	1.7	.6	2.5	1.4	.7	.7	.8
		Size	130	130	130	125	125	125	120	105
Cu	Dash-3	Mean	39.3	17.7	62.3	14.9	9.5	19.5	66.7	46.6
		StDev	4.1	6.9	7.7	1.1	.7	1.0	3.8	7.2
		Size	26	26	28	22	22	25	26	20
	FWMA	Mean	29.5	9.3	41.5	8.3	4.4	11.4	39.3	29.1
		StDev	6.8	1.8	9.7	2.5	5.0	1.9	9.8	9.7
		Size	130	130	130	125	125	125	120	105
Mg	Dash-3	Mean	12.1	22.1	38.1	16.7	44.7	3.8	29.9	50.6
		StDev	1.5	2.4	4.5	2.9	6.1	.9	6.9	13.9
		Size	26	26	28	22	22	25	26	20
	FWMA	Mean	4.8	11.0	27.3	8.1	25.5	1.4	12.3	24.3
		StDev	1.6	4.1	4.6	4.1	3.9	.7	4.9	5.2
		Size	130	130	130	125	125	125	120	105
Ni	Dash-3	Mean	10.6	17.8	51.6	12.9	5.1	21.7	23.8	7.9
		StDev	1.2	2.0	5.5	.9	.6	5.2	1.4	.9
		Size	26	26	28	22	22	25	26	20
	FWMA	Mean	7.3	11.4	30.2	8.3	3.7	14.4	14.0	5.4
		StDev	1.2	2.0	4.9	1.8	.6	1.6	2.9	1.5
		Size	130	130	130	125	125	125	120	105
Si	Dash-3	Mean	8.9	5.3	21.3	17.1	5.6	5.0	57.5	30.4
		StDev	2.4	1.8	2.9	2.2	6.5	2.2	7.5	3.4
		Size	26	26	28	22	22	25	26	20
	FWMA	Mean	1.9	1.0	8.8	2.5	1.1	2.0	17.9	7.3
		StDev	4.1	2.4	4.2	2.9	3.7	4.1	7.3	3.5
		Size	130	130	130	125	125	125	120	105
Ti	Dash-3	Mean	13.4	8.9	8.4	17.0	18.7	16.2	25.5	5.3
		StDev	1.8	1.9	2.4	1.8	2.2	1.9	1.8	2.2
		Size	26	26	28	22	22	25	26	20
	FWMA	Mean	7.2	5.2	5.9	10.6	13.3	9.9	14.5	3.1
		StDev	1.3	1.6	4.1	2.5	2.6	1.6	2.9	1.6
		Size	130	130	130	125	125	125	120	105

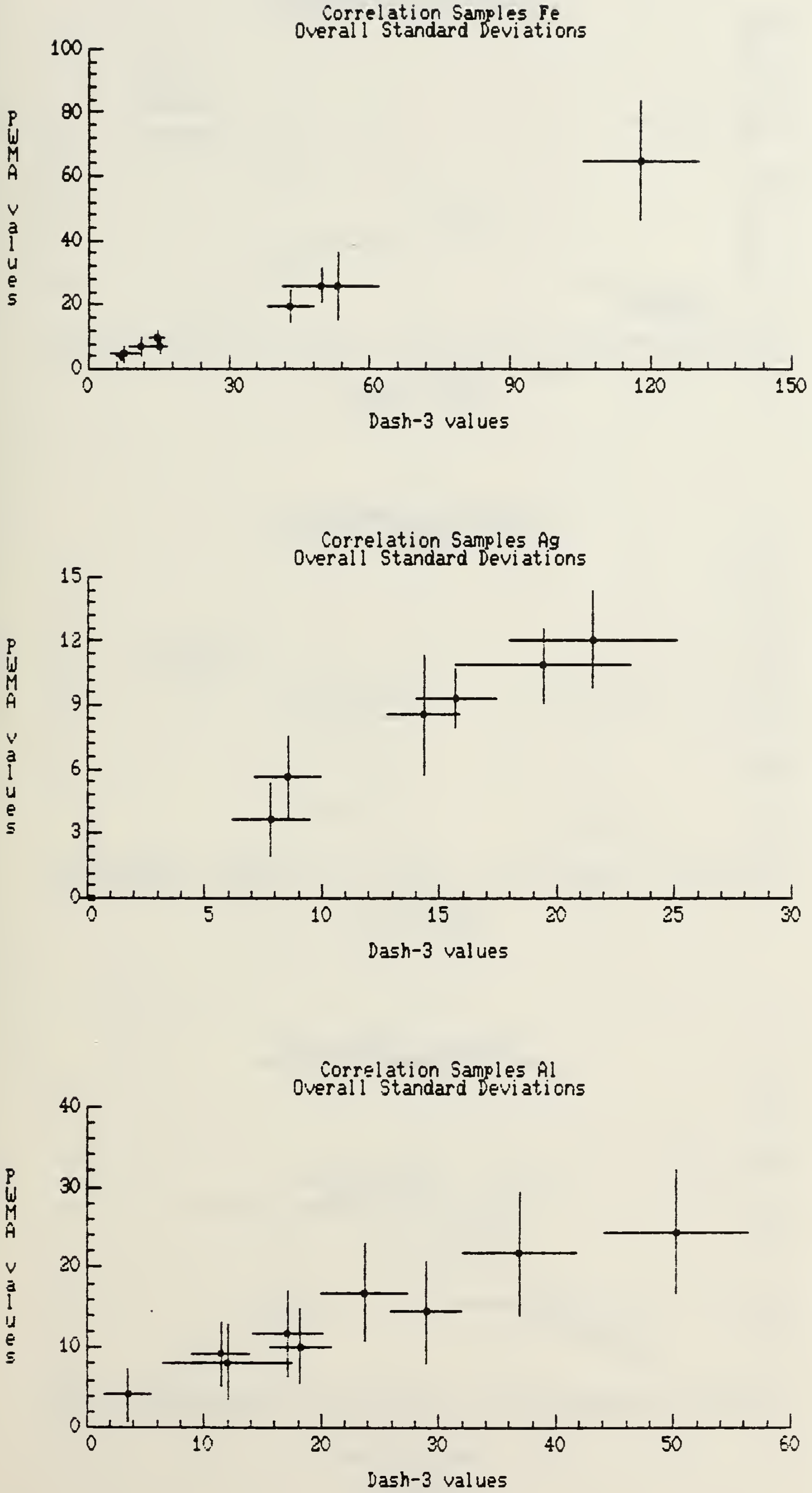

Correlation Samples Fe
Overall Standard Deviations
PWMA values
Dash-3 values
100
80
60
40
20
0
0
30
60
90
120
150
Correlation Samples Ag
Overall Standard Deviations
PWMA values
Dash-3 values
15
12
9
6
3
0
0
5
10
15
20
25
30
Correlation Samples Al
Overall Standard Deviations
PWMA values
Dash-3 values
40
30
20
10
0
0
10
20
30
40
50
60

Figure 1

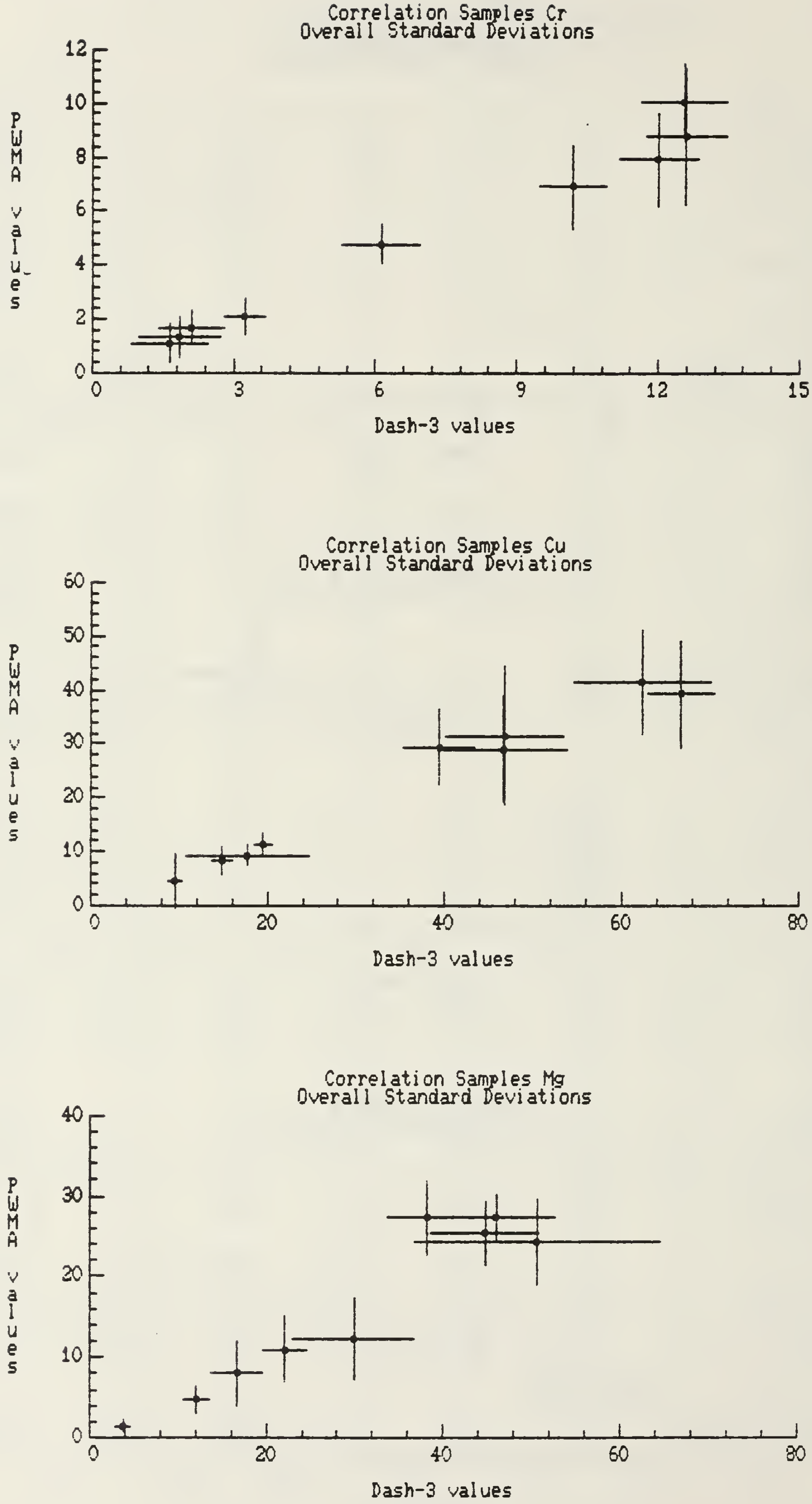
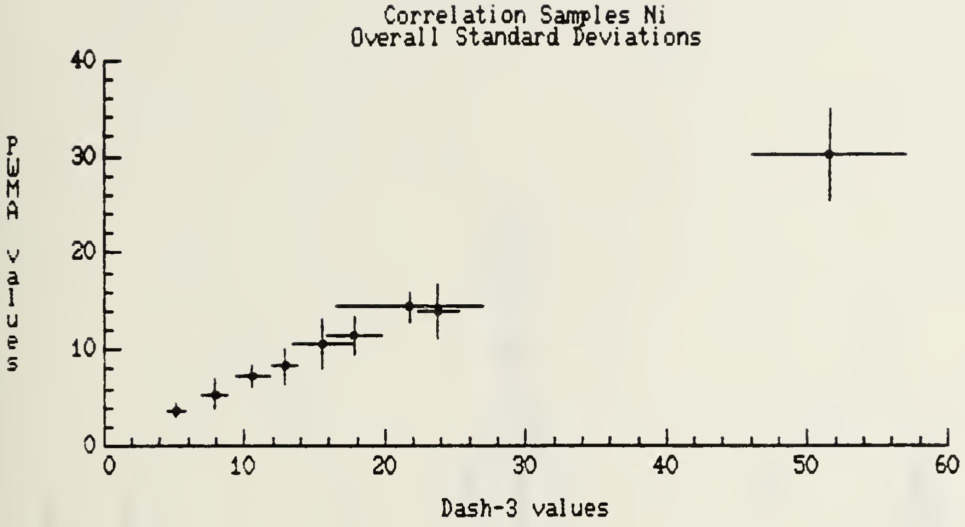
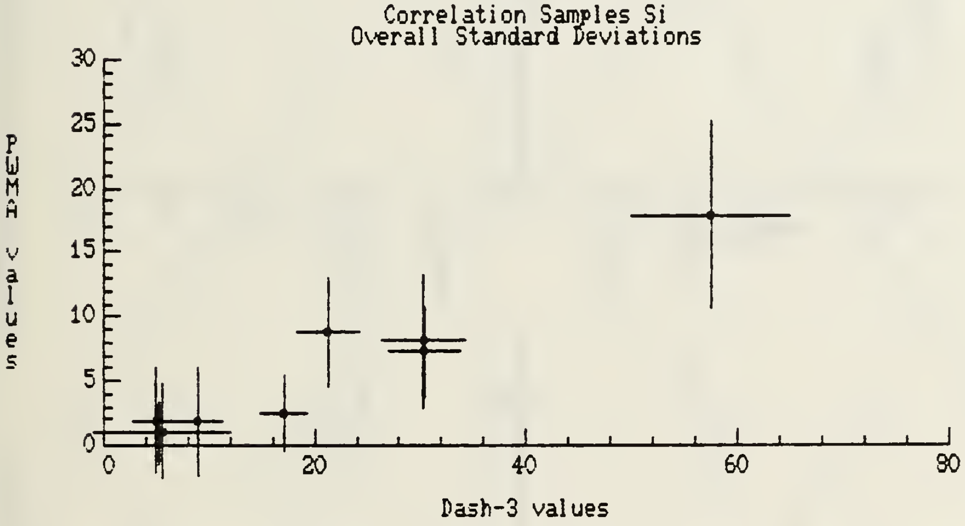

Correlation Samples Cr
Overall Standard Deviations
PWMA values
0
2
4
6
8
10
12
Dash-3 values
0
3
6
9
12
15
Correlation Samples Cu
Overall Standard Deviations
PWMA values
0
10
20
30
40
50
60
Dash-3 values
0
20
40
60
80
Correlation Samples Mg
Overall Standard Deviations
PWMA values
0
10
20
30
40
Dash-3 values
0
20
40
60
80

Figure 2


Correlation Samples Ni
Overall Standard Deviations
PWMA values
0
10
20
30
40
0
10
20
30
40
50
60
Dash-3 values


Correlation Samples Si
Overall Standard Deviations
PWMA values
0
5
10
15
20
25
30
0
20
40
60
80
Dash-3 values

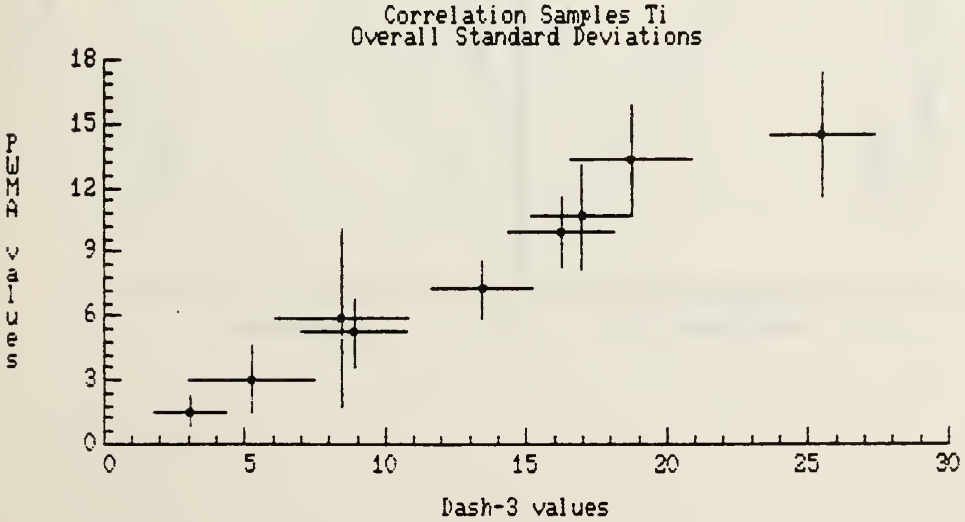

Correlation Samples Ti
Overall Standard Deviations
PWMA values
0
3
6
9
12
15
18
0
5
10
15
20
25
30
Dash-3 values

Figure 3

Figure 4 Correlation Samples

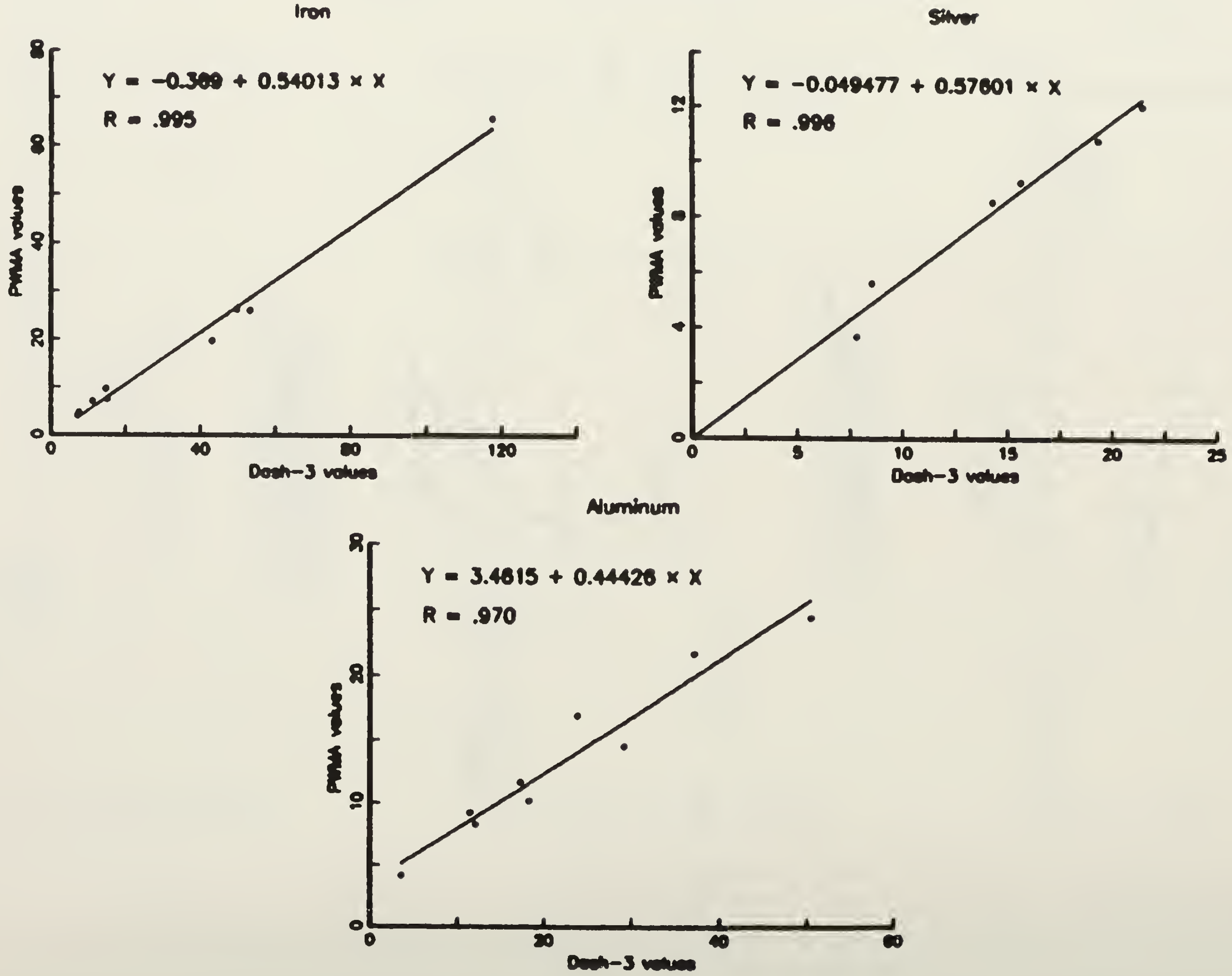


Figure 5 Correlation Samples

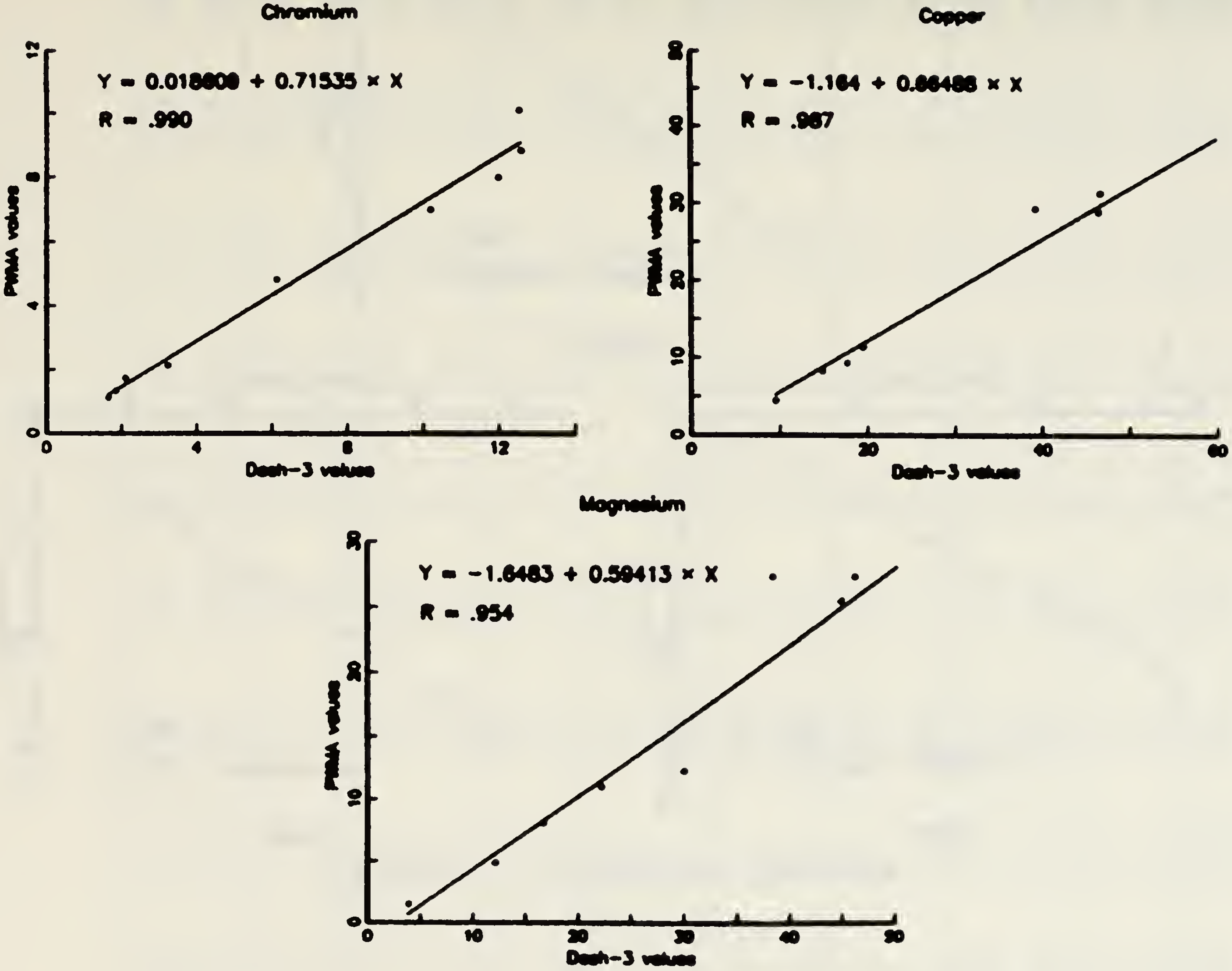


Figure 6 Correlation Samples

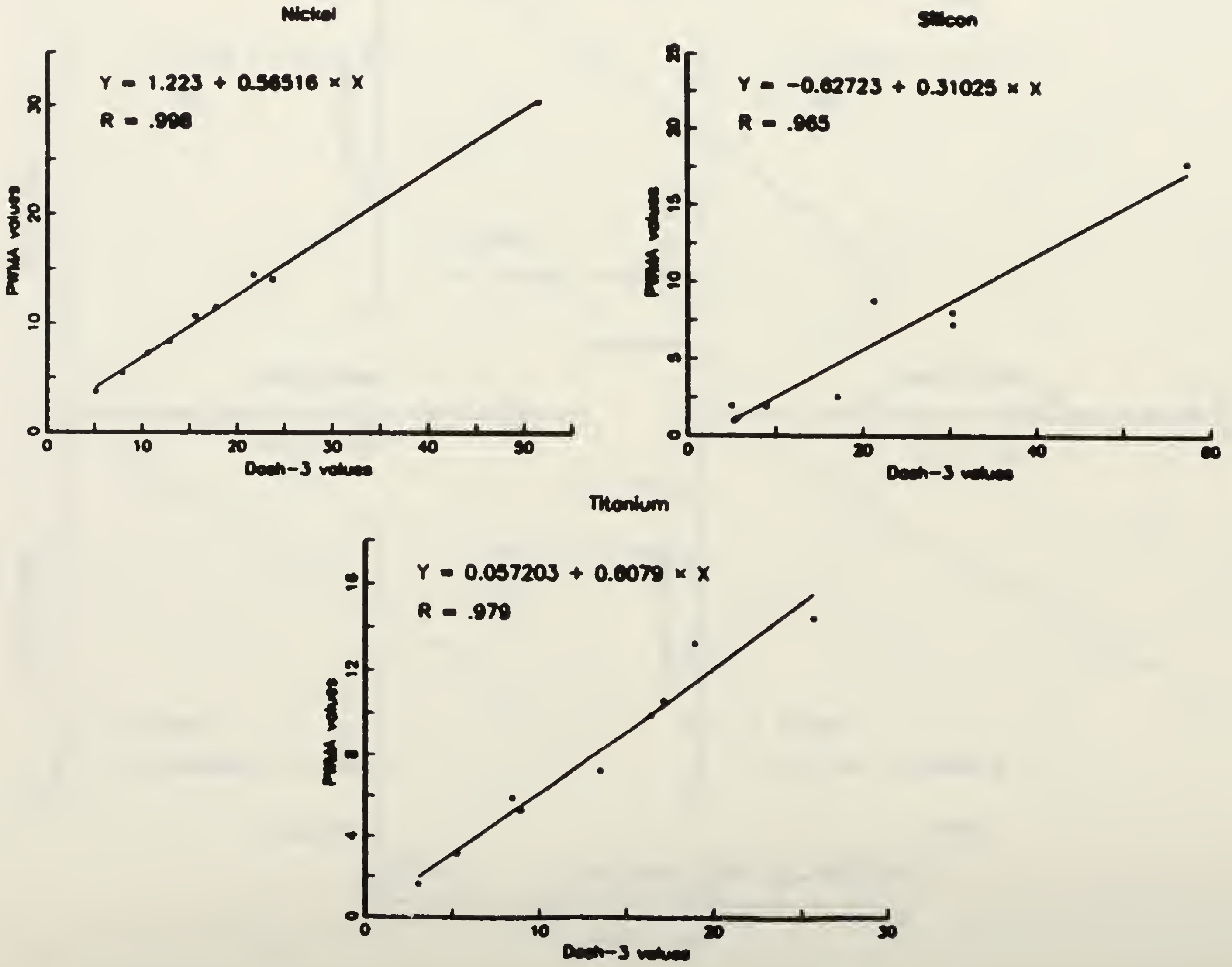
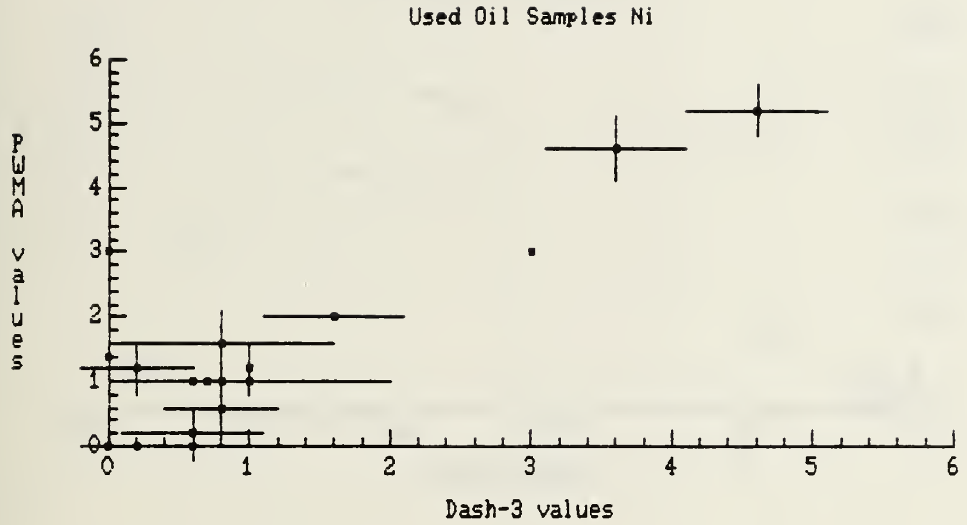


Table 40 Used Oil Samples Summary
First Ten Samples

		Element								
Inst	Stat	Fe	Ag	Al	Cr	Cu	Mg	Ni	Si	Ti
FWMA	Mean	13.0	.6	5.4	1.0	16.4	3.0	4.6	1.6	1.8
	StDev	1.4	.5	.5	.0	1.1	.0	.5	.5	1.1
Dash-3	Mean	9.6	1.0	4.0	1.8	18.2	2.0	3.6	2.8	.0
	StDev	.5	.0	.7	.4	.4	.0	.5	.8	.0
FWMA	Mean	19.6	.0	6.4	4.8	4.2	1.6	.6	1.2	.4
	StDev	.5	.0	.5	.4	.4	.5	.5	.4	.5
Dash-3	Mean	30.0	.0	9.4	9.6	7.2	4.0	.8	3.8	.0
	StDev	1.9	.0	1.3	.5	.4	.7	.4	.4	.0
FWMA	Mean	18.2	.0	8.8	3.4	6.0	2.4	.2	1.0	.0
	StDev	1.3	.0	.8	.5	.0	.5	.4	.0	.0
Dash-3	Mean	13.6	.0	9.4	3.6	6.0	3.0	.6	4.8	.0
	StDev	.9	.0	.5	.5	.0	.0	.5	.4	.0
FWMA	Mean	12.4	.0	1.0	.0	2.4	2.8	.0	.0	.0
	StDev	.5	.0	.0	.0	.5	.4	.0	.0	.0
Dash-3	Mean	15.4	.0	.0	.4	2.0	3.4	.2	1.8	.0
	StDev	1.7	.0	.0	.5	.0	.5	.4	.4	.0
FWMA	Mean	14.8	.0	3.0	1.0	3.0	4.0	.0	1.5	.2
	StDev	.8	.0	.7	.0	.0	.0	.0	.6	.4
Dash-3	Mean	16.8	.0	.8	.8	2.6	4.6	.0	4.2	.0
	StDev	3.6	.0	.8	.4	.5	.5	.0	2.7	.0
FWMA	Mean	73.4	.0	30.0	1.8	58.2	4.0	1.0	34.8	.6
	StDev	2.6	.0	1.2	.4	1.3	.0	.0	2.9	.5
Dash-3	Mean	89.3	.0	30.0	2.7	100.0	5.0	.7	73.3	.0
	StDev	2.5	.0	1.0	.6	.0	.0	.6	2.5	.0
FWMA	Mean	52.0	.0	19.0	1.0	49.8	3.0	1.0	23.8	.8
	StDev	1.9	.0	2.3	.0	1.1	.0	.0	1.3	.4
Dash-3	Mean	60.6	.0	19.6	2.0	66.0	3.6	.8	48.8	.0
	StDev	4.0	.0	1.1	.0	3.4	.5	.4	4.1	.0
FWMA	Mean	68.8	.0	7.0	1.0	4.4	2.0	.0	.8	.0
	StDev	1.3	.0	.0	.0	.5	.0	.0	.4	.0
Dash-3	Mean	67.4	.0	11.2	1.0	4.4	1.2	.6	4.4	.0
	StDev	1.7	.0	.8	.0	.5	.4	.5	1.1	.0
FWMA	Mean	79.8	.0	6.0	2.0	1.0	6.2	2.0	18.6	.4
	StDev	2.5	.0	.0	.0	.0	.8	.0	3.2	.5
Dash-3	Mean	74.8	.0	2.4	2.2	1.0	9.4	1.6	15.6	.4
	StDev	4.8	.0	1.3	.4	.0	.5	.5	.9	.5
FWMA	Mean	50.0	.0	8.0	3.8	5.8	.6	1.2	1.2	.8
	StDev	2.0	.0	.0	.4	.8	.5	.4	.4	.8
Dash-3	Mean	27.0	.0	7.0	3.2	4.0	1.0	.2	2.4	.0
	StDev	1.4	.0	.7	.4	.0	.0	.4	.5	.0

Table 40 Used Oil Samples Summary
Last Ten Samples

			Element							
No	Inst	Stat	Fe	Ag	Al	Cr	Cu	Mg	Ni	Si
1	FWMA	Mean	70.4	.0	9.2	7.6	7.2	.8	1.0	3.0
		StDev	5.7	.0	.4	.9	.8	.4	.0	1.0
	Dash-3	Mean	44.2	.0	11.2	6.6	4.6	.0	.8	4.8
		StDev	3.7	.0	1.5	.5	.5	.0	.4	.8
2	FWMA	Mean	84.8	.0	17.6	4.8	21.2	8.8	1.6	1.4
		StDev	2.6	.0	8.3	.4	1.1	1.1	.5	.5
	Dash-3	Mean	151.0	.0	31.4	6.2	19.2	11.4	.8	9.6
		StDev	16.6	.0	2.1	.4	1.5	1.1	.8	.9
3	FWMA	Mean	102.4	.0	2.0	2.0	4.4	5.4	1.0	2.2
		StDev	4.6	.0	.0	.0	.5	.5	.0	1.6
	Dash-3	Mean	296.8	1.0	3.4	3.4	5.0	12.2	1.0	6.0
		StDev	30.8	.0	1.1	.5	.0	1.6	1.0	1.0
4	FWMA	Mean	62.8	.0	6.8	9.6	5.4	1.6	1.0	.8
		StDev	7.4	.0	1.1	1.5	.5	.5	.0	.8
	Dash-3	Mean	42.0	.0	9.0	10.8	6.6	.6	.8	4.0
		StDev	3.8	.0	1.0	.4	.5	.5	.8	.7
5	FWMA	Mean	121.6	1.0	2.8	2.0	5.0	6.6	3.0	6.8
		StDev	1.1	.0	.4	.0	1.2	.5	1.2	1.1
	Dash-3	Mean	156.2	1.0	1.8	2.4	5.0	9.0	.0	6.4
		StDev	8.8	.0	1.3	.5	.0	.7	.0	.5
6	FWMA	Mean	116.4	1.0	.6	2.8	1.0	.0	1.2	3.8
		StDev	1.3	.0	1.3	.4	1.0	.0	.4	2.9
	Dash-3	Mean	166.0	1.0	.0	3.8	.2	.0	1.0	.2
		StDev	6.0	.0	.0	.4	.4	.0	.0	.4
7	FWMA	Mean	122.4	1.2	.8	3.0	.6	.0	1.0	2.4
		StDev	3.2	.4	.8	.0	.5	.0	.0	.5
	Dash-3	Mean	153.6	1.0	.0	3.2	.2	.0	.6	27.4
		StDev	9.1	.0	.0	.4	.4	.0	.5	28.3
8	FWMA	Mean	14.6	1.0	6.4	1.6	17.4	3.0	5.2	3.8
		StDev	2.1	.0	1.5	.5	.5	.0	.4	2.5
	Dash-3	Mean	11.8	1.0	7.4	2.0	20.8	3.0	4.6	4.4
		StDev	.4	.0	.9	.0	.4	.0	.5	1.1
9	FWMA	Mean	13.6	.8	7.4	1.4	14.6	2.0	3.0	2.8
		StDev	1.5	.4	.5	.5	1.3	.0	.0	1.3
	Dash-3	Mean	10.2	1.0	7.8	1.6	14.6	2.0	3.0	3.2
		StDev	1.1	.0	.8	.5	1.3	.0	.0	.8
10	FWMA	Mean	53.6	.0	1.0	1.2	1.0	1.6	1.4	2.4
		StDev	3.3	.0	.0	.4	1.2	.5	.5	2.1
	Dash-3	Mean	44.0	.0	.4	.4	.6	.4	.0	9.8
		StDev	3.2	.0	.5	.5	.5	.5	.0	.8


Used Oil Samples Ni
PWMA values
0
1
2
3
4
5
6
Dash-3 values
0
1
2
3
4
5
6

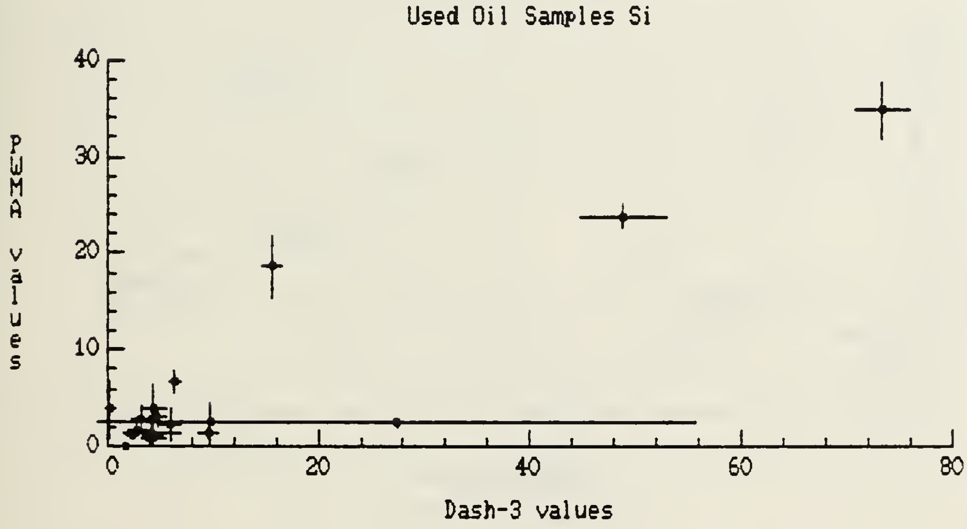
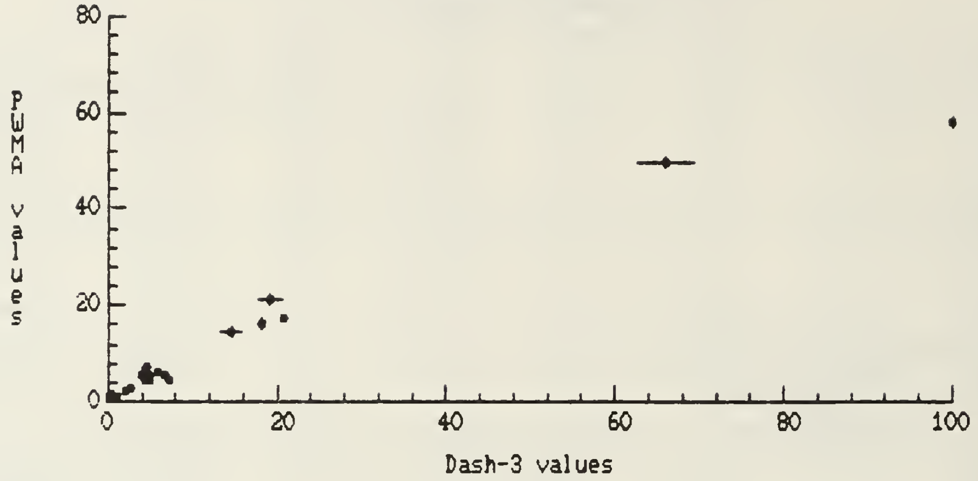
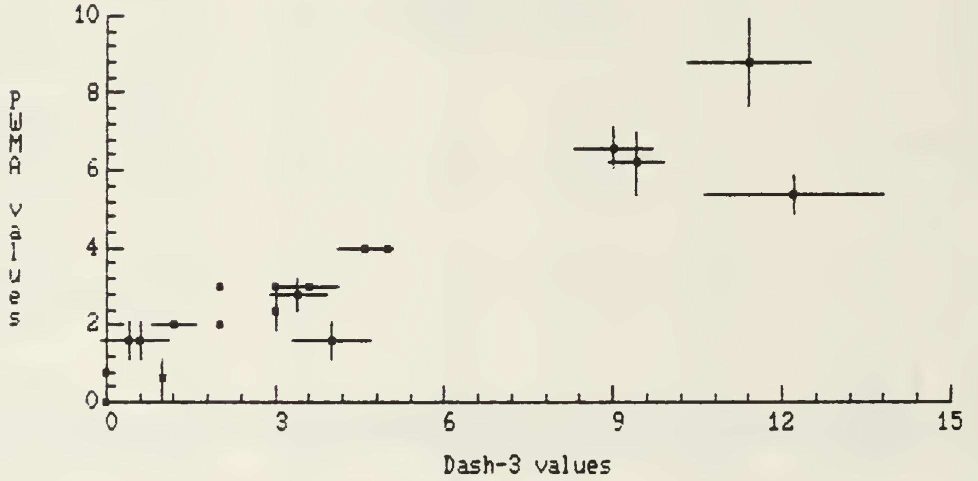

Used Oil Samples Si
PWMA values
0
10
20
30
40
Dash-3 values
0
20
40
60
80

Figure 9

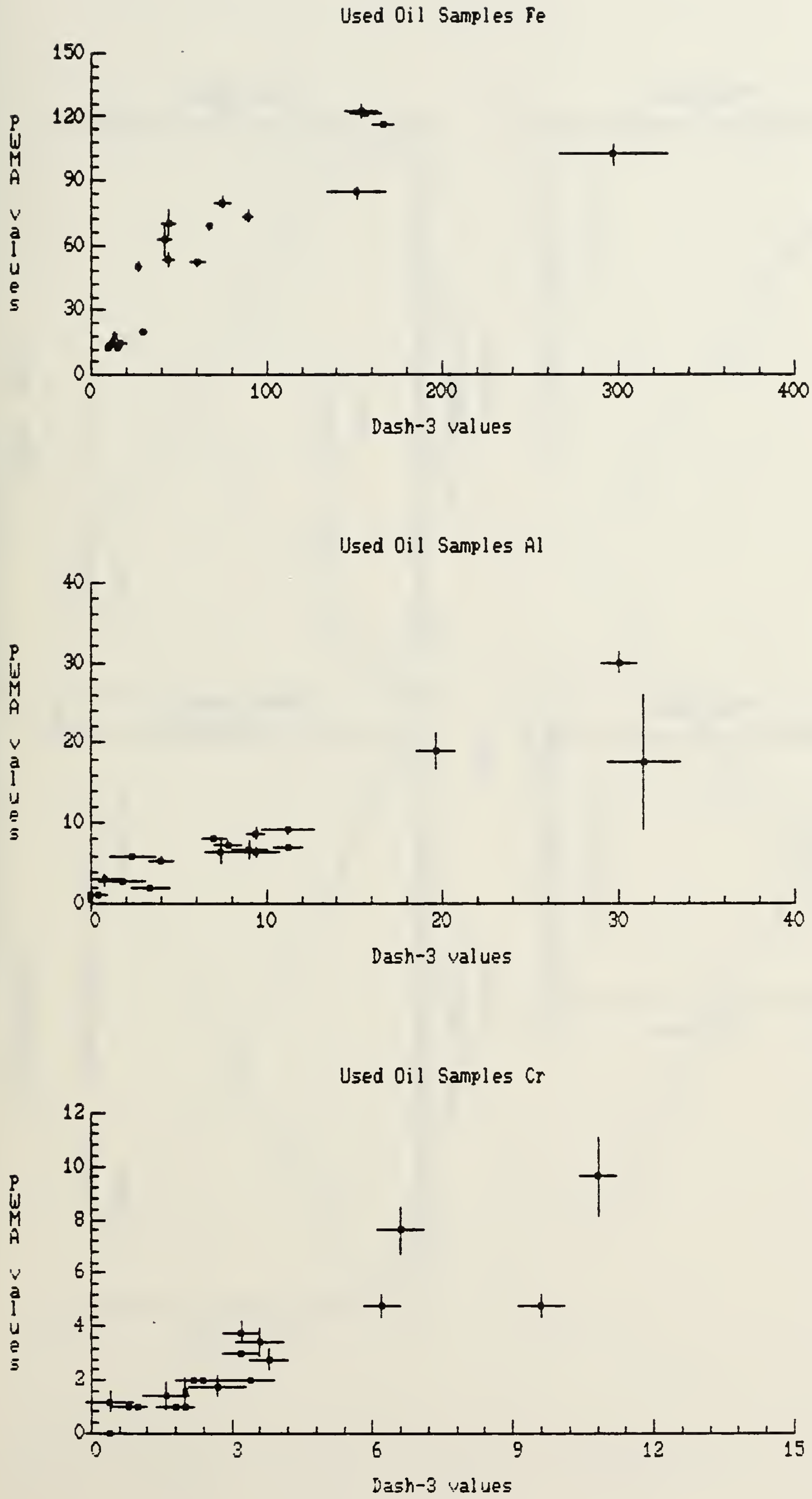


Used Oil Samples Cu



Used Oil Samples Mg

Figure 8


Used Oil Samples Fe

Used Oil Samples Al

Used Oil Samples Cr

Figure 7

Figure 10 Used Oil Samples

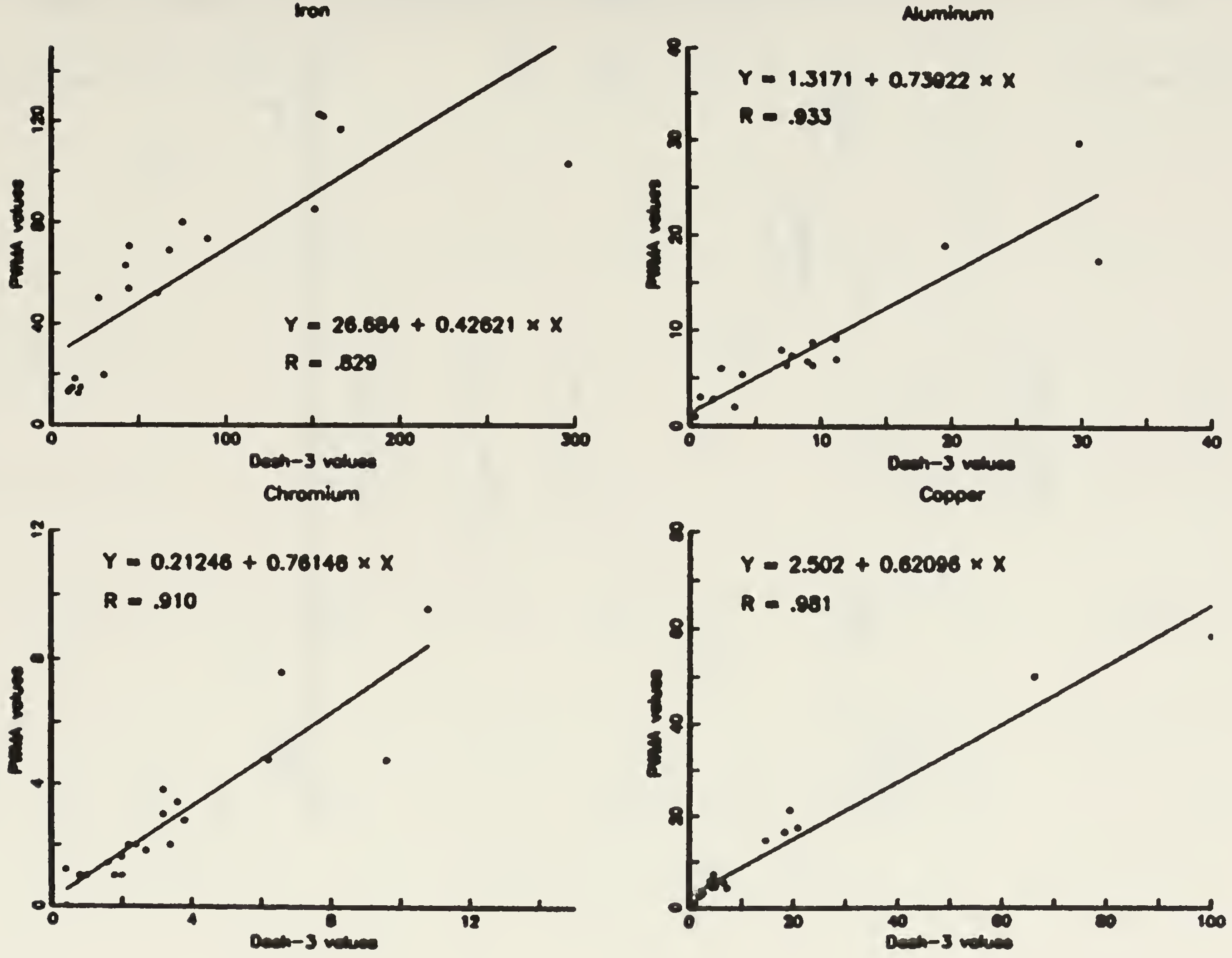


Figure 11 Used Oil Samples

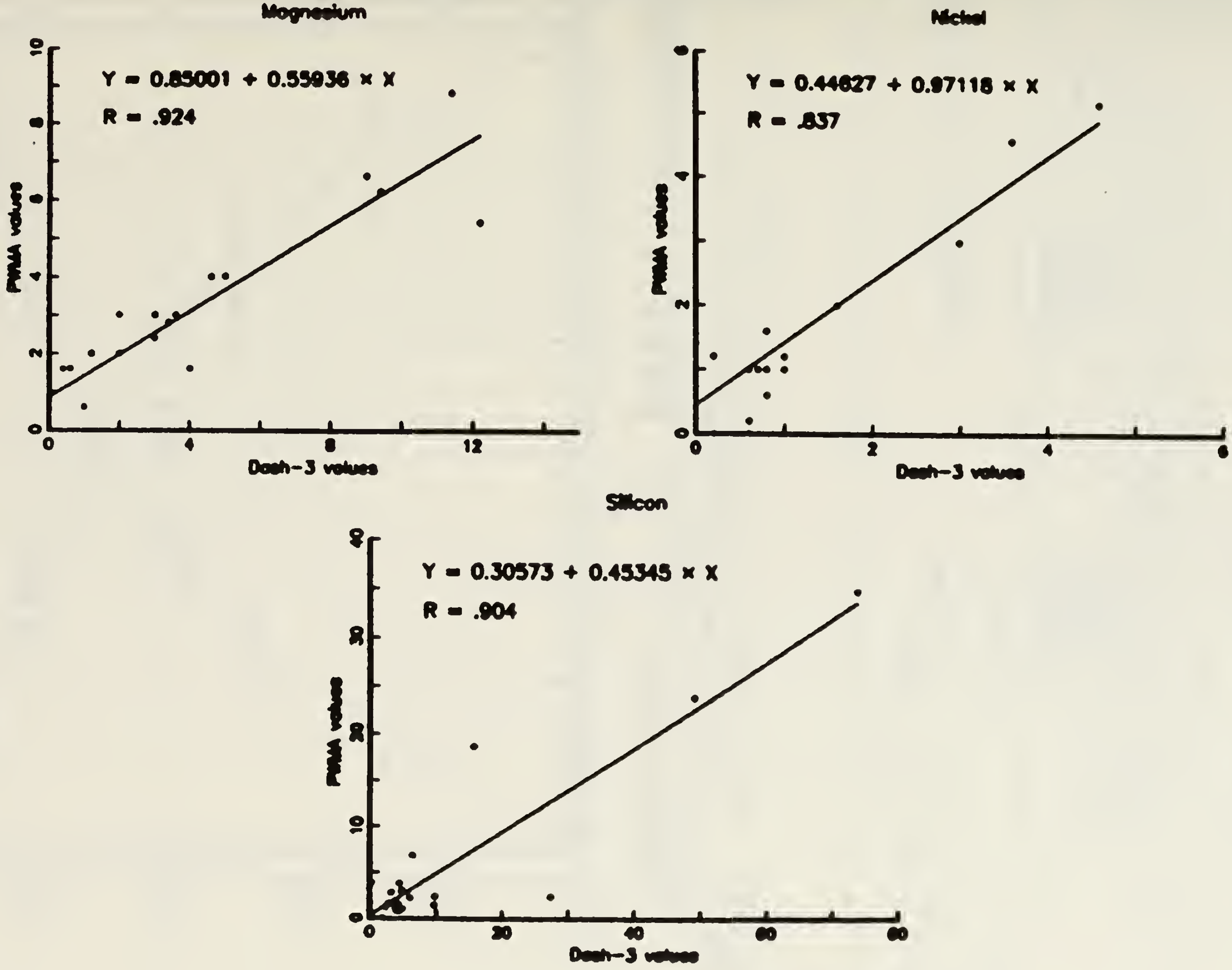


Figure 12

```
Exponential model: Y = exp(a+bX) of FEPPM on FEABS
                                  Standard                  T                 Prob.
Parameter          Estimate         Error                 Value               Level
------------------------------------------------------------------------------------
Intercept           2.12713       0.0686235             30.9971                   0
Slope             0.0172425     7.02548E?4              24.5428                   0

------------------------------------------------------------------------------------
                     Analysis of Variance
------------------------------------------------------------------------------------
Source                 Sum of Squares       Df  Mean Square     F-Ratio
Model                        17.20077        1   17.20077      602.34855
Error                         .856685       30    .028556
------------------------------------------------------------------------------------
Total (Corr.)               18.057451       31

Correlation Coefficient = 0.975991
Stnd. Error of Est. = 0.168986

Do you want to plot the fitted line? (Y/N):


 1HELP    2LABEL   3SAVSC   4RECORD 5PLTPAR 6       7       8        9REVIEW 10
PRINT     THR OCT 17  1985 09:48:00 AM  VERSION 1.1                       APL RE
```

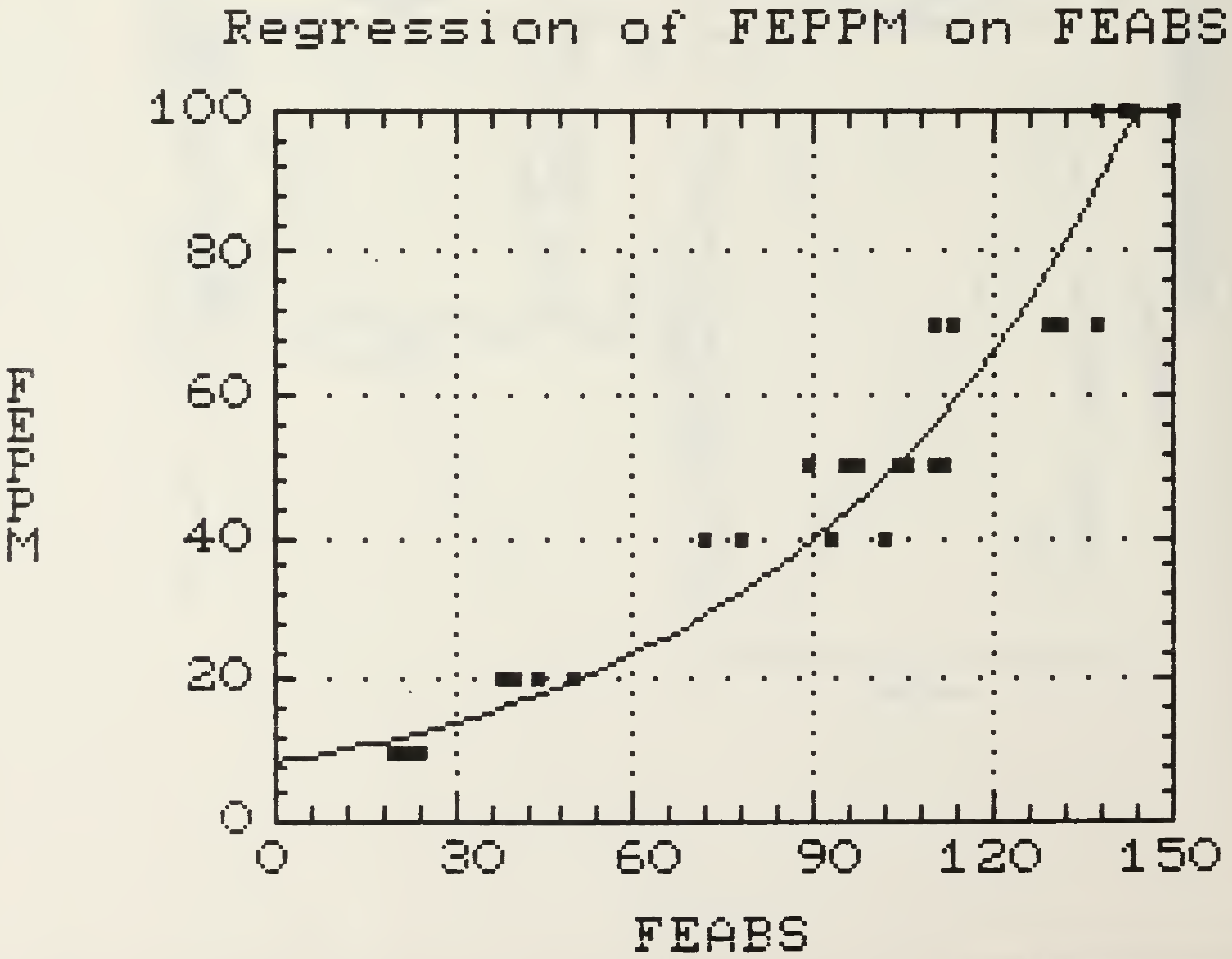
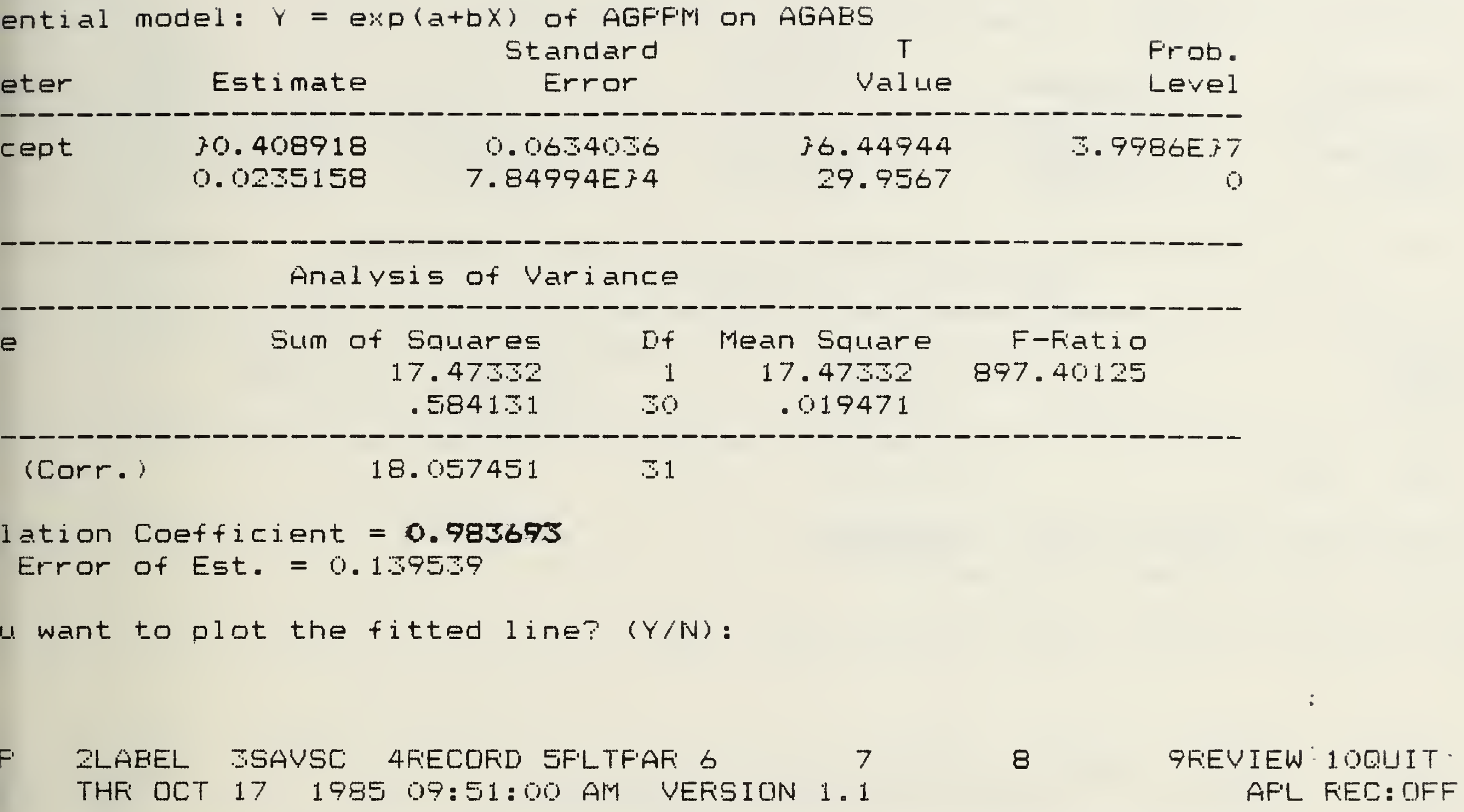


Figure 13



```
ential model: Y = exp(a+bX) of AGFPM on AGABS
                           Standard              T              Prob.
eter          Estimate       Error             Value            Level
-------------------------------------------------------------------------
cept         }0.408918     0.0634036         }6.44944        3.9986E}7
             0.0235158     7.84994E}4         29.9567               0

-------------------------------------------------------------------------
                Analysis of Variance
-------------------------------------------------------------------------
e               Sum of Squares       Df  Mean Square     F-Ratio
                      17.47332        1     17.47332   897.40125
                       .584131       30      .019471
-------------------------------------------------------------------------
 (Corr.)             18.057451       31

lation Coefficient = 0.983693
 Error of Est. = 0.139539

u want to plot the fitted line? (Y/N):



F    2LABEL   3SAVSC   4RECORD 5PLTPAR 6        7        8        9REVIEW 10QUIT
    THR OCT 17  1985 09:51:00 AM   VERSION 1.1                        APL REC:OFF
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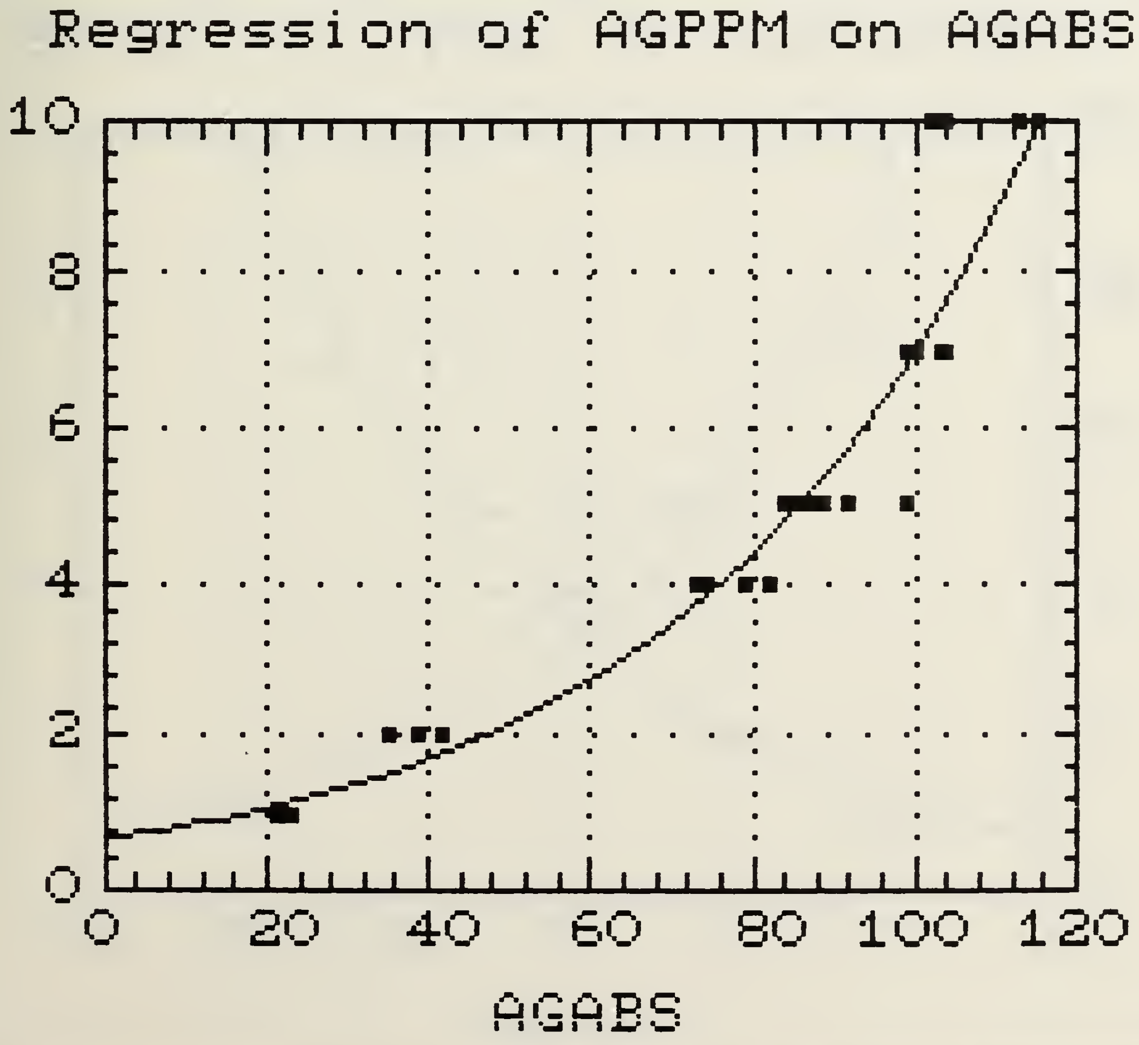


Figure 14

```
Exponential model: Y = exp(a+bX) of ALPPM on ALABS
                                  Standard              T              Prob.
Parameter          Estimate        Error              Value            Level
-----------------------------------------------------------------------------
Intercept          0.625543        0.10656            5.87033      2.00441E-6
Slope              0.104419     6.24801E-3            16.7124               0

-----------------------------------------------------------------------------
                     Analysis of Variance
-----------------------------------------------------------------------------
Source                    Sum of Squares     Df   Mean Square     F-Ratio
Model                           16.30603      1      16.30603   279.30474
Error                           1.751423     30       .058381
-----------------------------------------------------------------------------
Total (Corr.)                  18.057451     31

Correlation Coefficient = 0.950267
Stnd. Error of Est. = 0.241621

Do you want to plot the fitted line? (Y/N):


 1HELP    2LABEL   3SAVSC   4RECORD 5PLTPAR 6        7        8        9REVIEW 10Q
PRINT     THR OCT 17  1985 09:55:00 AM  VERSION 1.1                          AFL REC
```

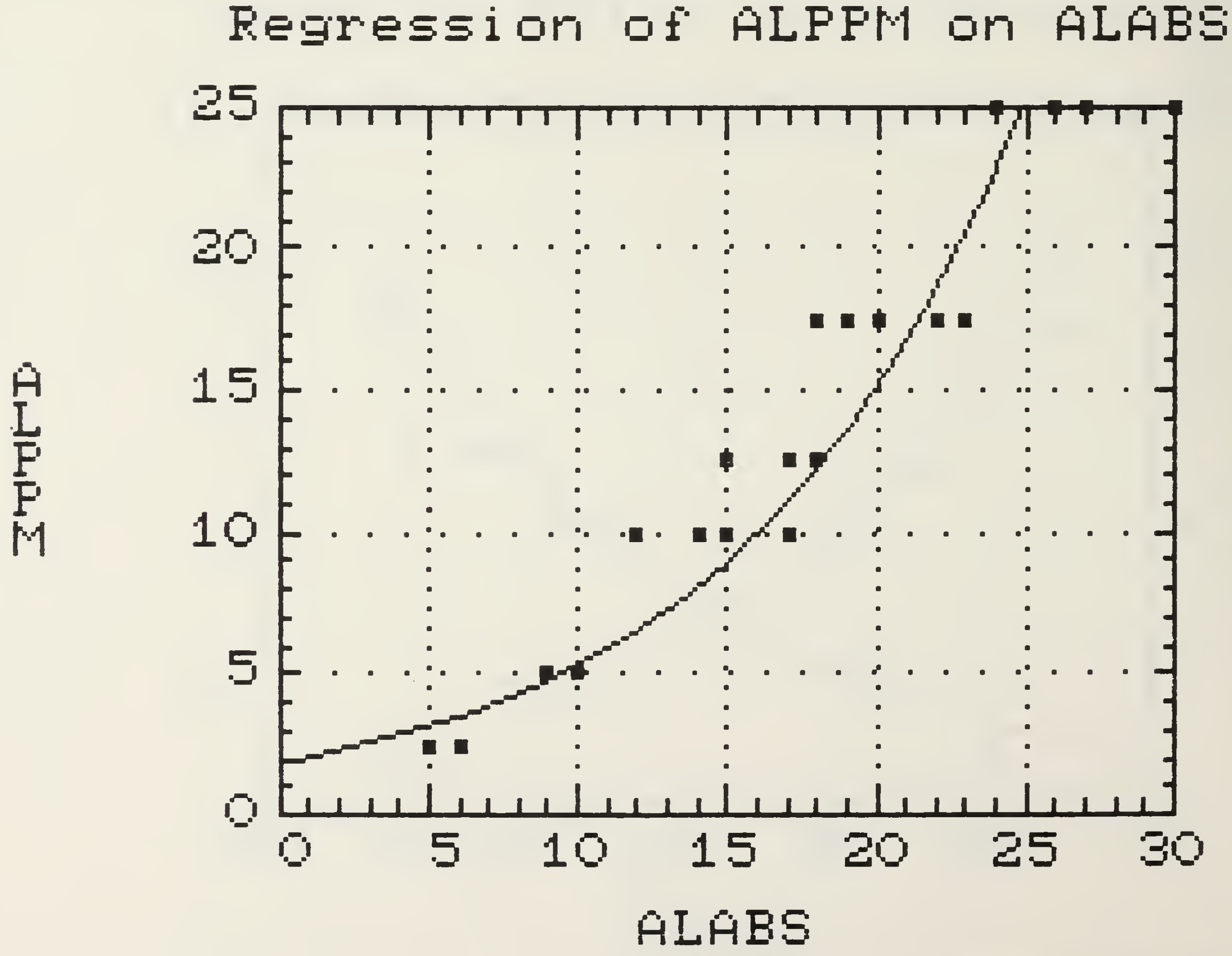


Figure 15

```
ential model: Y = exp(a+bX) of CRPPM on CRABS
                            Standard            T              Prob.
eter          Estimate        Error           Value            Level
--------------------------------------------------------------------
cept         }0.254362     0.0608972        }4.1769       2.34326E}4
              0.024961    8.64838E}4        28.8621                0

--------------------------------------------------------------------
               Analysis of Variance
--------------------------------------------------------------------
e              Sum of Squares      Df   Mean Square     F-Ratio
                     17.42975       1      17.42975   833.02115
                      .627706      30       .020924
--------------------------------------------------------------------
 (Corr.)            18.057451      31

lation Coefficient = 0.982465
 Error of Est. = 0.14465

u want to plot the fitted line? (Y/N):

                                                                      :

F    2LABEL   3SAVSC   4RECORD 5PLTPAR 6       7        8        9REVIEW 10QUIT
    WED OCT 16  1985 11:20:00 AM   VERSION 1.1                      APL REC:OFF
```

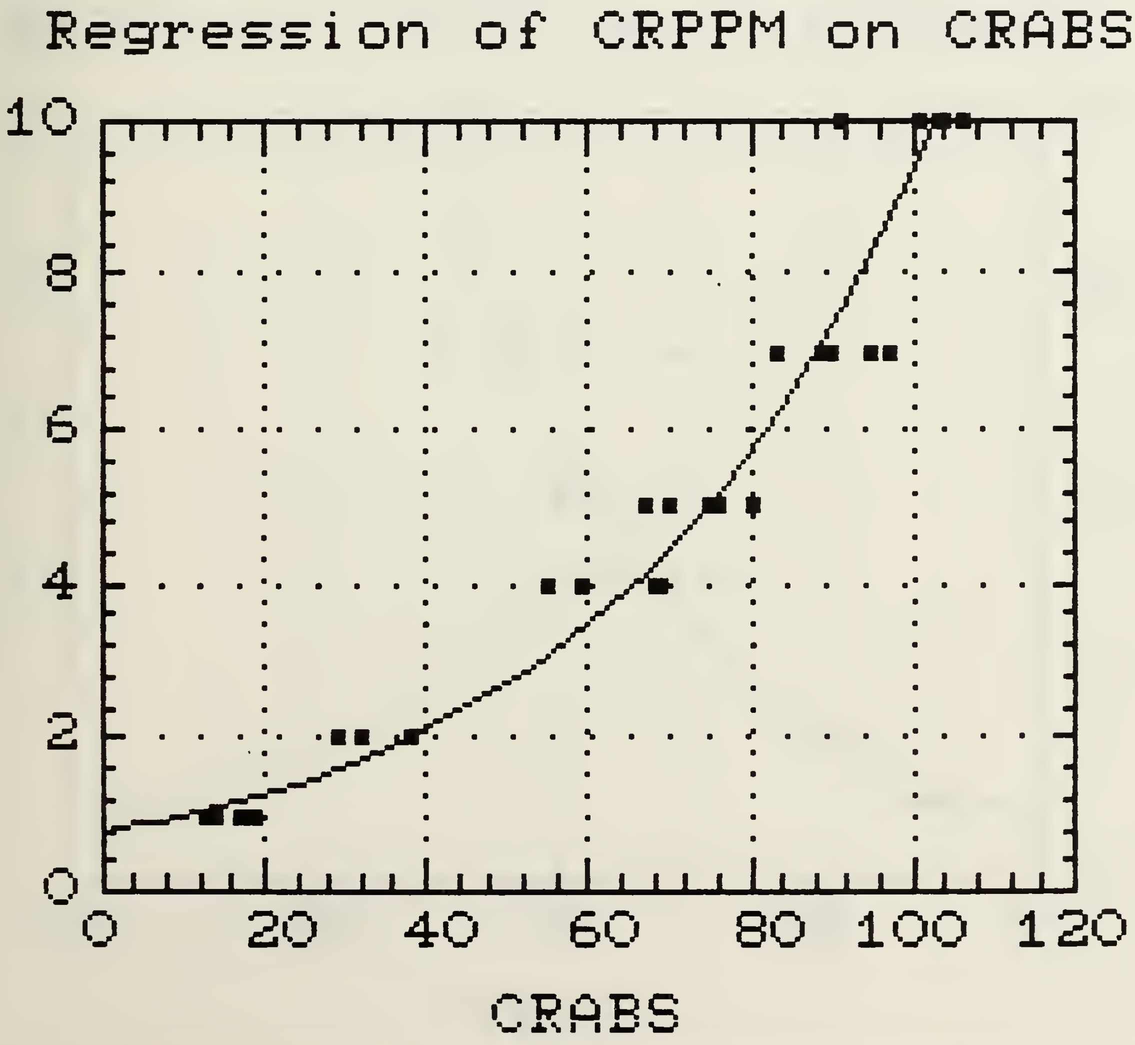
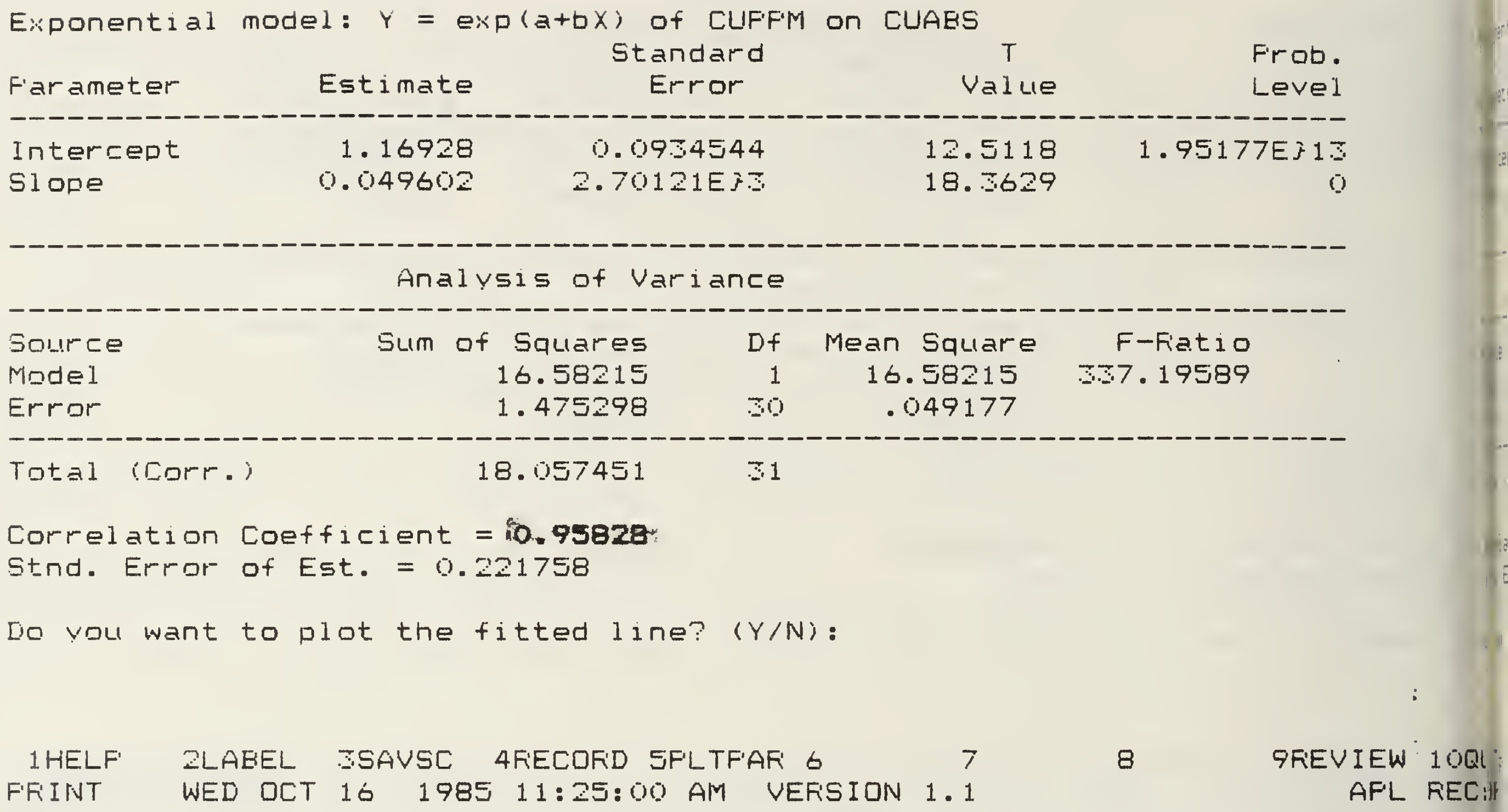


Figure 16



```
Exponential model: Y = exp(a+bX) of CUPPM on CUABS
                                    Standard                 T               Prob.
Parameter          Estimate          Error                 Value             Level
-----------------------------------------------------------------------------------
Intercept           1.16928        0.0934544              12.5118       1.95177E}13
Slope              0.049602        2.70121E}3             18.3629                 0

-----------------------------------------------------------------------------------
                      Analysis of Variance
-----------------------------------------------------------------------------------
Source                    Sum of Squares      Df   Mean Square      F-Ratio
Model                           16.58215       1     16.58215     337.19589
Error                           1.475298      30      .049177
-----------------------------------------------------------------------------------
Total (Corr.)                  18.057451      31

Correlation Coefficient = 0.95828
Stnd. Error of Est. = 0.221758

Do you want to plot the fitted line? (Y/N):


 1HELP    2LABEL   3SAVSC   4RECORD 5PLTPAR 6        7        8          9REVIEW 10QU
PRINT     WED OCT 16  1985 11:25:00 AM  VERSION 1.1                              APL REC
```

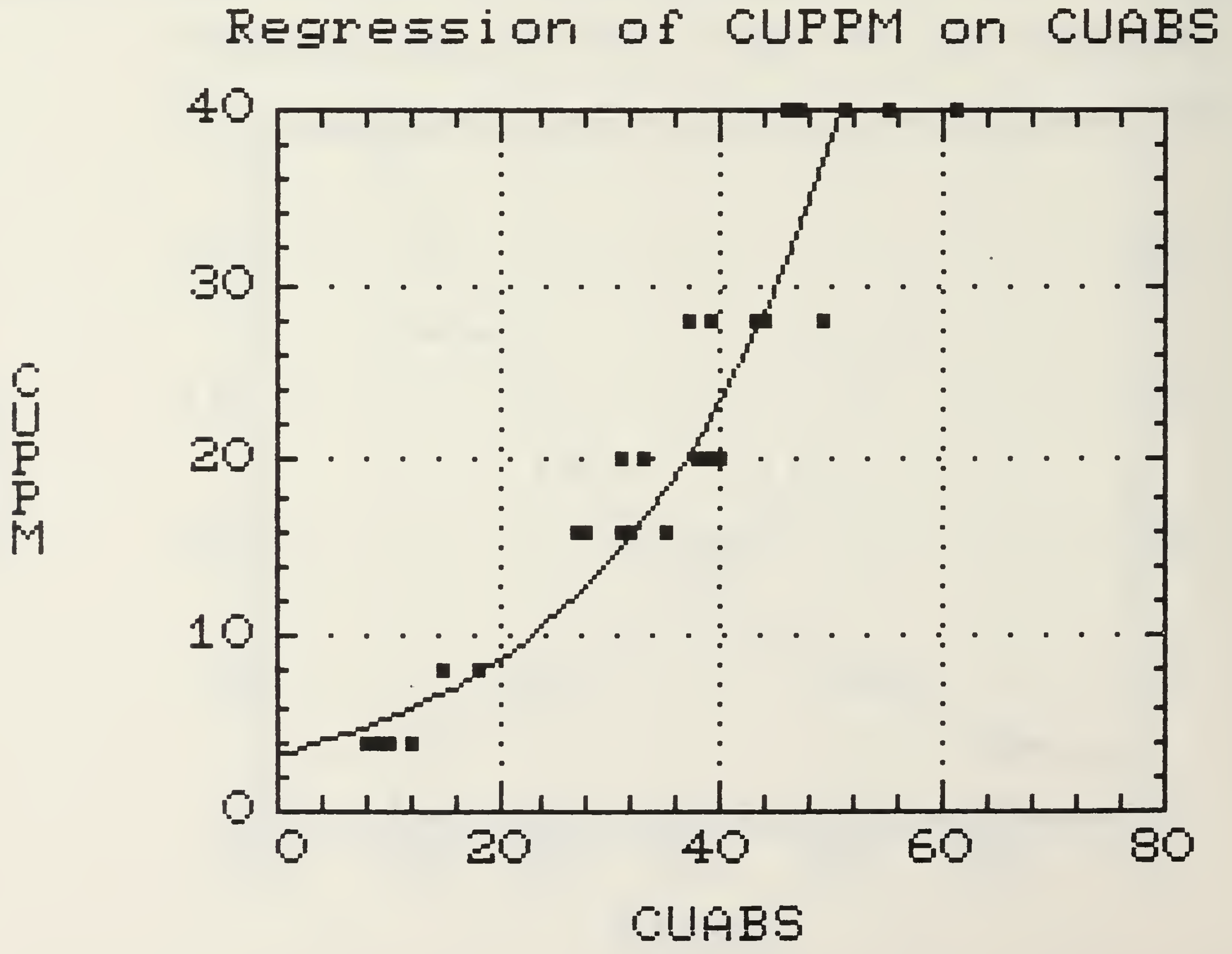


Figure 17

```
ential model: Y = exp(a+bX) of MGPPM on MGABS
                              Standard                T               Prob.
eter          Estimate          Error               Value             Level
----------------------------------------------------------------------------
cept         )0.199394        0.114433            )1.74245        0.0916742
             0.0351084       1.56778E)3            22.3936                0

----------------------------------------------------------------------------
                Analysis of Variance
----------------------------------------------------------------------------
                Sum of Squares      Df   Mean Square     F-Ratio
                      17.03817       1      17.03817   501.47463
                      1.019284      30       .033976
----------------------------------------------------------------------------
  (Corr.)            18.057451      31

lation Coefficient = 0.971367
d Error of Est. = 0.184326

u want to plot the fitted line? (Y/N):
```

```
     2LABEL  3SAVSC  4RECORD 5PLTPAR 6       7        8        9REVIEW 10QUIT
     WED OCT 16  1985 11:30:00 AM  VERSION 1.1                     APL REC:OFF
```

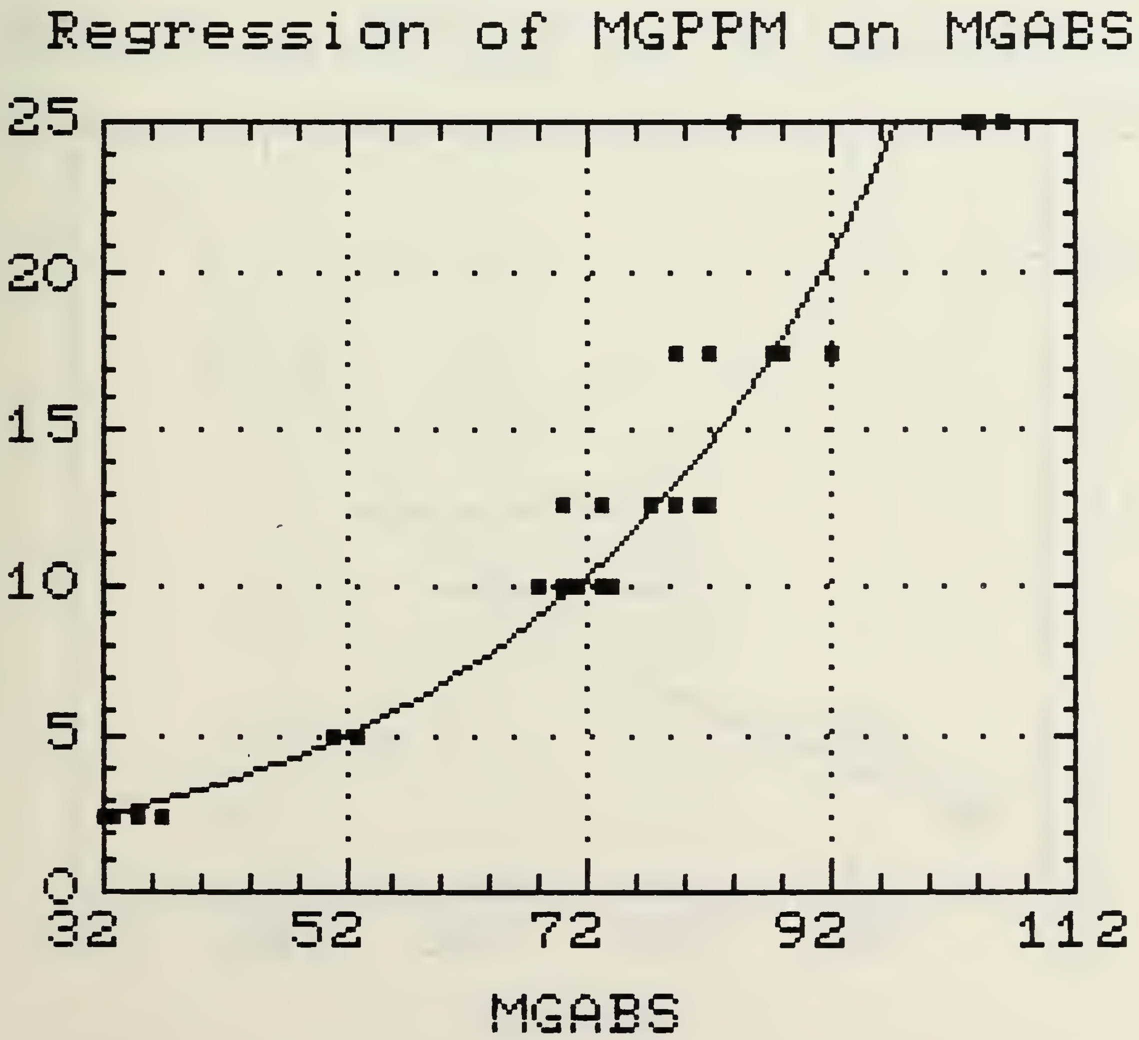


Figure 18

```
Exponential model: Y = exp(a+bX) of NIPPM on NIABS
                                  Standard                 T                Prob.
Parameter           Estimate        Error                Value              Level
--------------------------------------------------------------------------------
Intercept            1.14158      0.0678847            16.8164                  0
Slope               0.016091     7.33863E-4            21.9264                  0

--------------------------------------------------------------------------------
                       Analysis of Variance
--------------------------------------------------------------------------------
Source                     Sum of Squares       Df   Mean Square    F-Ratio
Model                            16.99684        1      16.99684   480.76759
Error                            1.060607       30       .035354
--------------------------------------------------------------------------------
Total (Corr.)                   18.057451       31

Correlation Coefficient = 0.970188'
Stnd. Error of Est. = 0.188025

Do you want to plot the fitted line? (Y/N):


 1HELP    2LABEL   3SAVSC   4RECORD 5PLTPAR 6        7        8         9REVIEW 10G
PRINT     WED OCT 16  1985 12:53:00 PM  VERSION 1.1                         APL REC
```

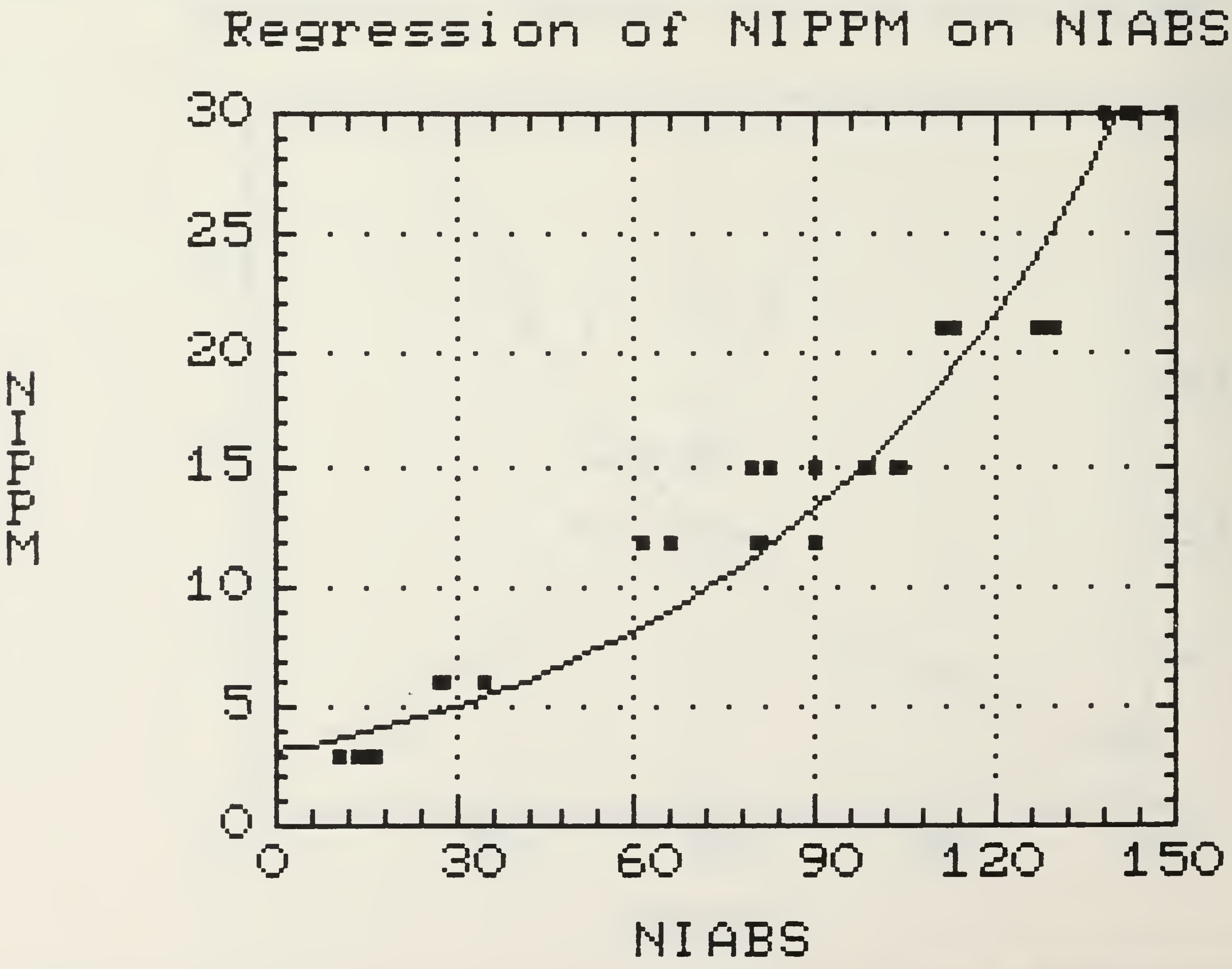
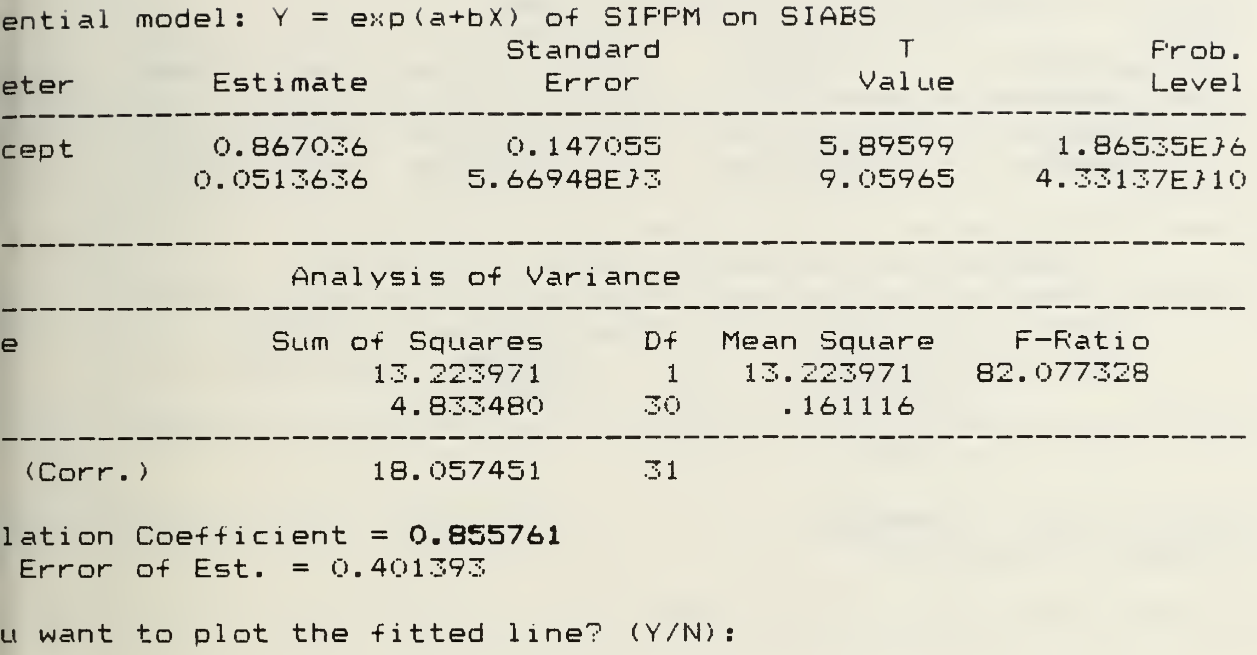


Figure 19



```
ential  model:  Y = exp(a+bX)  of  SIFPM  on  SIABS
                                  Standard                    T                Prob.
eter           Estimate             Error                  Value               Level
-------------------------------------------------------------------------------------
cept           0.867036            0.147055              5.89599           1.86535E}6
              0.0513636          5.66948E}3              9.05965          4.33137E}10

-------------------------------------------------------------------------------------
                         Analysis  of  Variance
-------------------------------------------------------------------------------------
e                   Sum of Squares          Df    Mean Square      F-Ratio
                         13.223971           1      13.223971    82.077328
                          4.833480          30        .161116
-------------------------------------------------------------------------------------
 (Corr.)                 18.057451          31

lation Coefficient  = 0.855761
 Error  of  Est.  = 0.401393

u want  to plot  the  fitted line?  (Y/N):
```

```
F    2LABEL   3SAVSC   4RECORD 5PLTPAR 6          7          8          9REVIEW 10QUIT
    WED OCT 16   1985 12:57:00 PM   VERSION 1.1                                APL REC:OFF
```

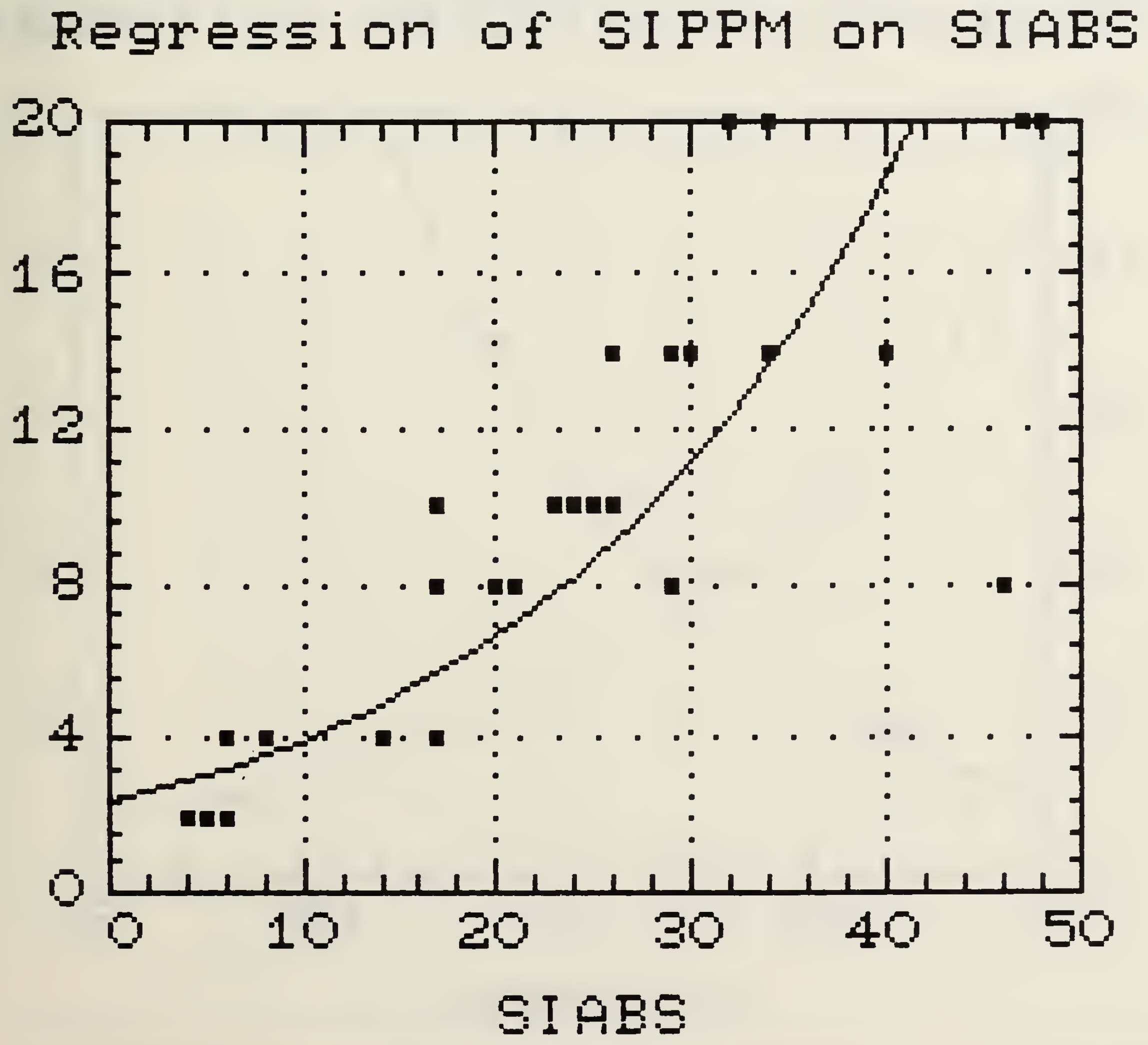


Figure 20

```
Exponential model: Y = exp(a+bX) of TIPPM on TIABS
                                 Standard                T               Prob.
Parameter         Estimate         Error               Value             Level
-------------------------------------------------------------------------------
Intercept         0.754188       0.0939064            8.03128       5.77862E}9
Slope            0.0404269      2.59512E}3             15.578      6.66134E}16

-------------------------------------------------------------------------------
                     Analysis of Variance
-------------------------------------------------------------------------------
Source                     Sum of Squares      Df   Mean Square     F-Ratio
Model                            16.07075       1      16.07075   242.67481
Error                            1.986702      30       .066223
-------------------------------------------------------------------------------
Total (Corr.)                   18.057451      31

Correlation Coefficient = 0.943387
Stnd. Error of Est. = 0.257339

Do you want to plot the fitted line? (Y/N):


 1HELP    2LABEL   3SAVSC   4RECORD 5PLTPAR 6        7        8         9REVIEW 10Q
PRINT     WED OCT 16  1985 01:01:00 PM  VERSION 1.1                         APL REC
```

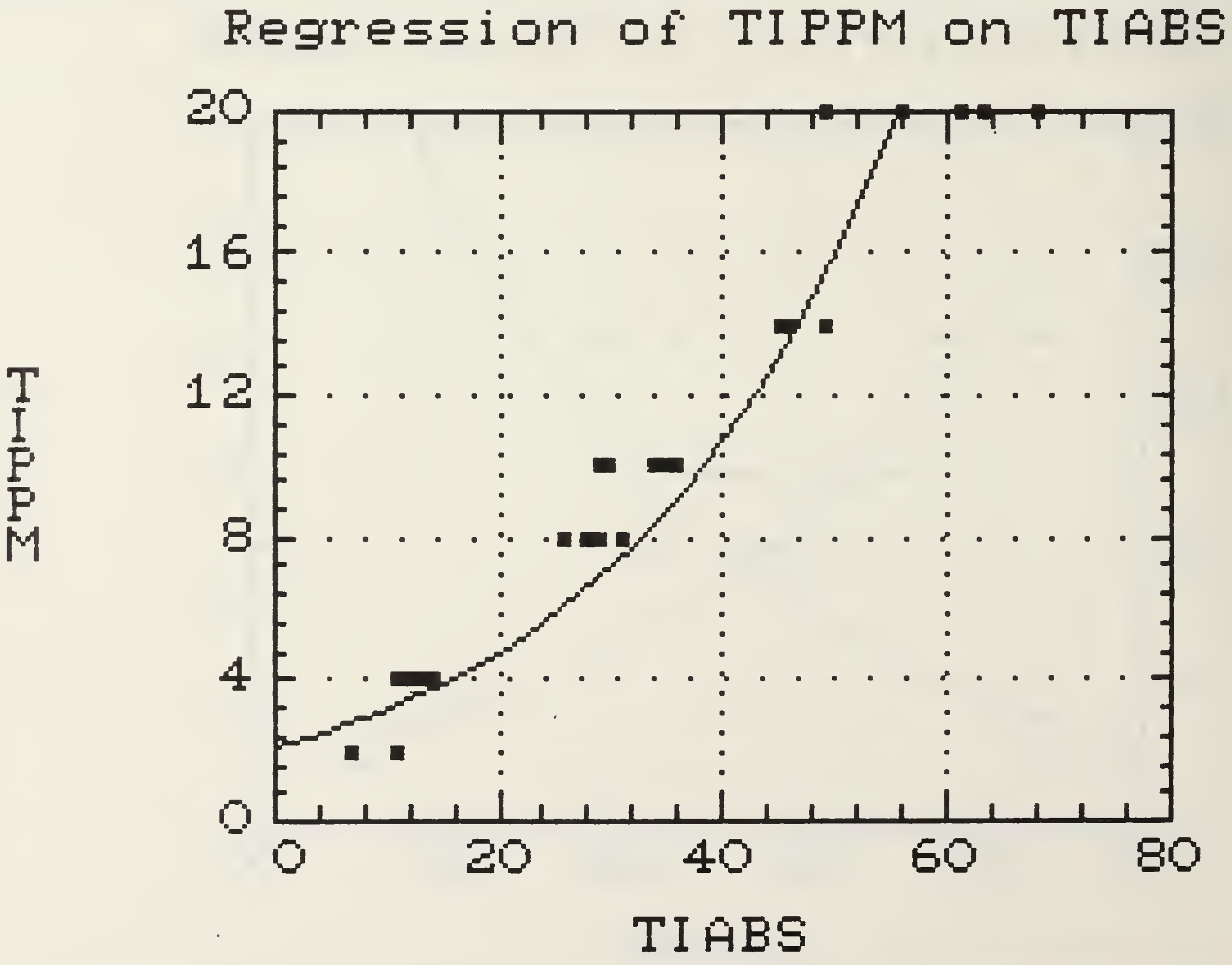


Figure 21

```
                                Standard                  T                 Frob.
eter          Estimate            Error                 Value               Level
-----------------------------------------------------------------------------------
cept           2.02823          0.077145              26.2911         1.46021E)10
              0.017144        7.46743E)4              22.9584          5.5497E)10

-----------------------------------------------------------------------------------
                   Analysis of Variance
-----------------------------------------------------------------------------------
e                   Sum of Squares      Df   Mean Square     F-Ratio
                           7.02806       1       7.02806   527.08818
                          .1333375      10      .0133338
-----------------------------------------------------------------------------------
 (Corr.)                  7.161401      11

lation Coefficient = 0.990647
 Error of Est. = 0.115472

u want to plot the fitted line? (Y/N):

                                                                                    :
P    2LABEL   3SAVSC   4RECORD 5PLTPAR 6        7          8          9REVIEW 10QUIT
     WED OCT 16  1985 02:22:00 PM  VERSION 1.1                              APL REC:OFF
```

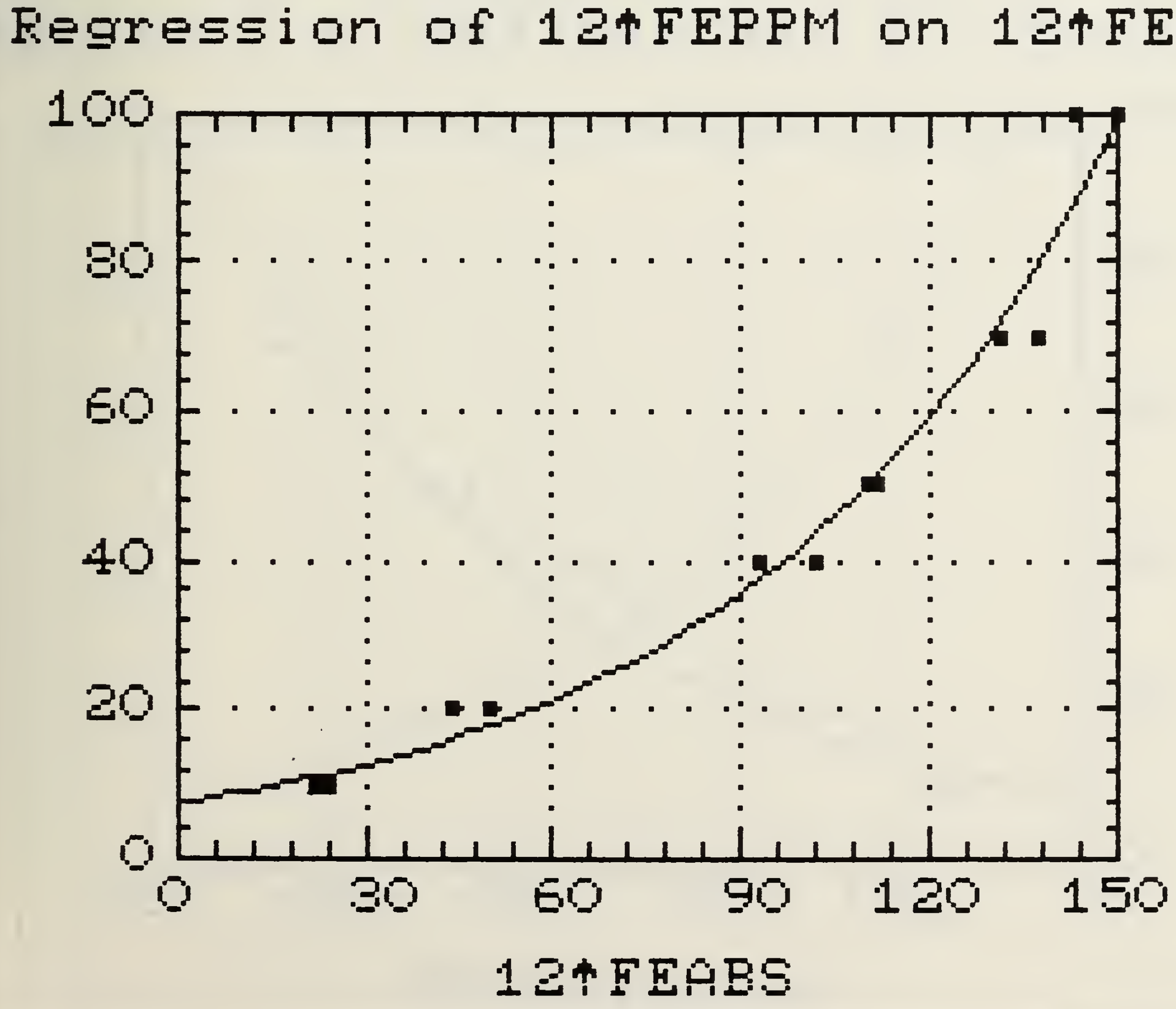


Figure 22

```
12FEABS
                                       Standard               T                 Prob.
Parameter           Estimate            Error               Value               Level
-------------------------------------------------------------------------------------
Intercept             2.0856           0.111556            18.6955          1.64458E}8
Slope              0.0177076         1.16632E}3            15.1824          1.01562E}7

-------------------------------------------------------------------------------------
                        Analysis of Variance
-------------------------------------------------------------------------------------
Source                   Sum of Squares       Df   Mean Square      F-Ratio
Model                          5.66556         1       5.66556    230.50634
Error                         .2212088         9      .0245788
-------------------------------------------------------------------------------------
Total (Corr.)                5.8867673        10

Correlation Coefficient = 0.981031
Stnd. Error of Est. = 0.156776

Do you want to plot the fitted line? (Y/N):


 1HELP    2LABEL   3SAVSC   4RECORD 5PLTPAR 6        7        8          9REVIEW 10G
PRINT     WED OCT 16   1985 02:26:00 PM  VERSION 1.1                          APL REC
```

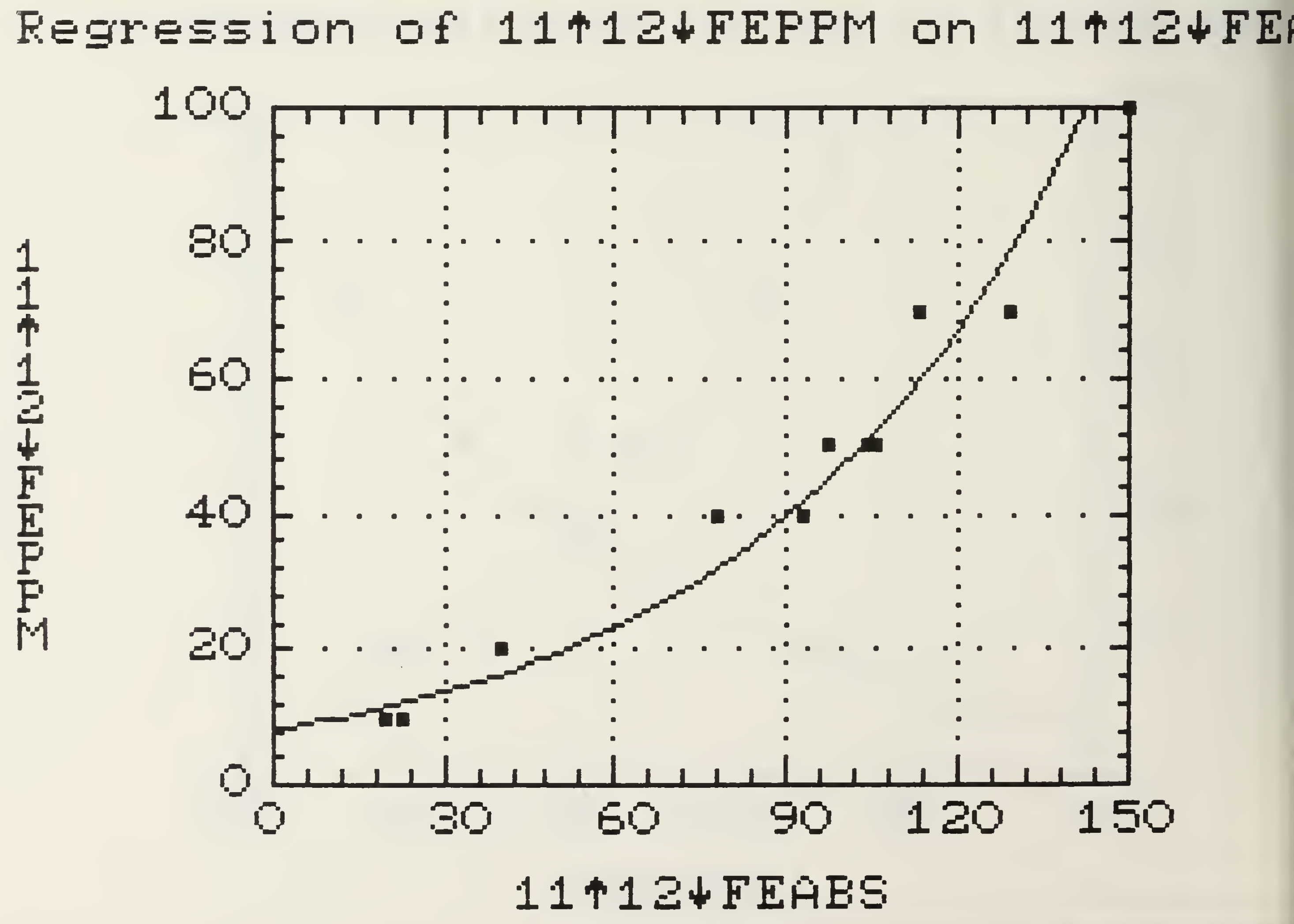


Figure 23

```
                              Standard                T                   Frob.
eter          Estimate          Error               Value                 Level
-----------------------------------------------------------------------------
cept           2.23074        0.113955             19.5755            2.2663E}7
             0.0177512      1.23516E}3             14.3717            1.8801E}6

-----------------------------------------------------------------------------
                      Analysis of Variance
-----------------------------------------------------------------------------
e                   Sum of Squares       Df   Mean Square     F-Ratio
                          4.81112         1       4.81112   206.54435
                         .1630536         7      .0232934
-----------------------------------------------------------------------------
 (Corr.)                4.9741689         8

lation Coefficient = 0.983473
 Error of Est. = 0.152622

u want to plot the fitted line? (Y/N):


F    2LABEL   3SAVSC   4RECORD 5PLTPAR 6         7          8          9REVIEW 10QUIT
     WED OCT 16   1985 02:30:00 PM   VERSION 1.1                         APL REC:OFF
```

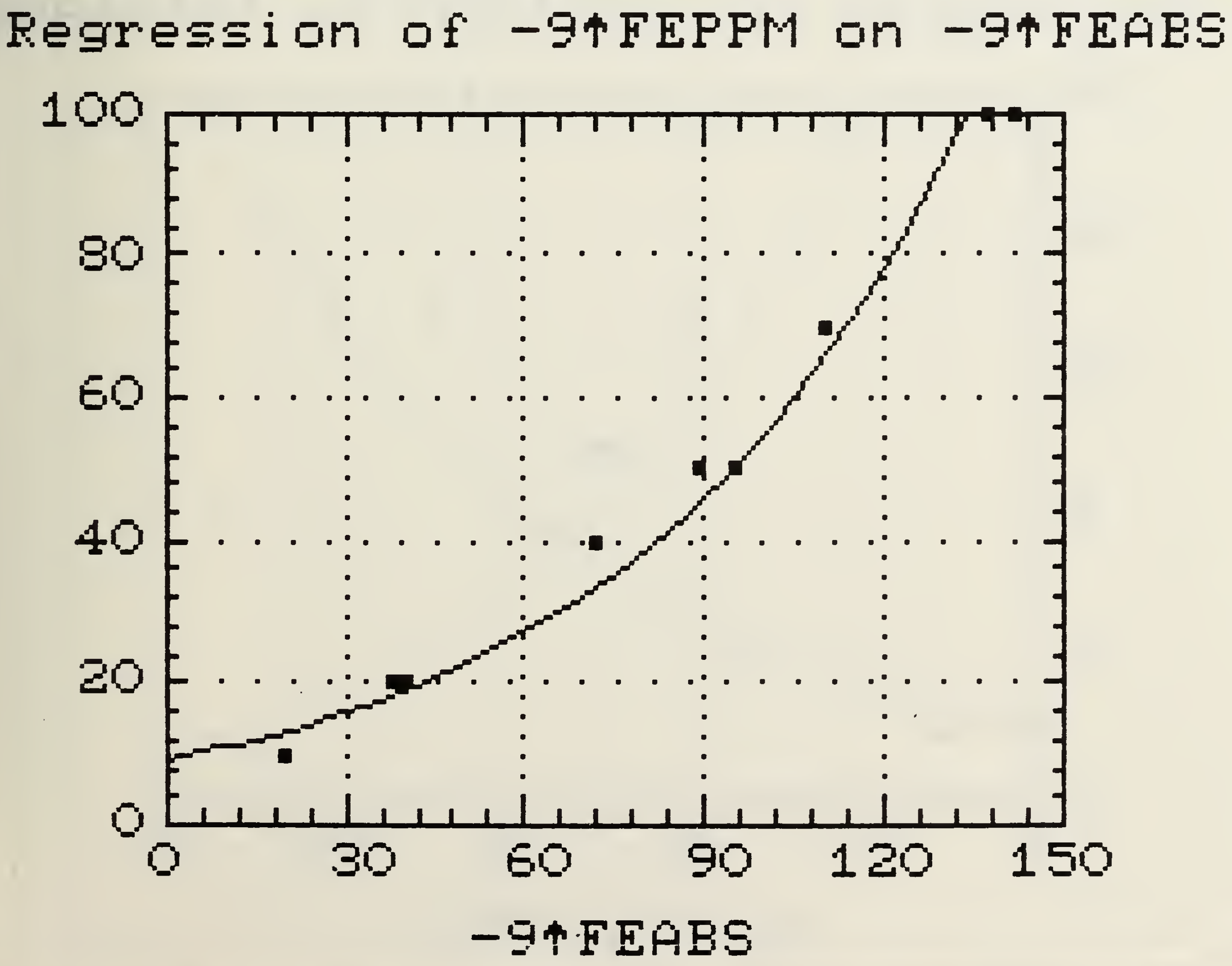


Figure 24

```
SIABS
                                  Standard              T             Prob.
Parameter        Estimate          Error              Value           Level
---------------------------------------------------------------------------
Intercept        0.695262        0.280362           2.47987         0.03255
Slope           0.0490692      9.31056E)3           5.27028      3.62666E)4

---------------------------------------------------------------------------
                     Analysis of Variance
---------------------------------------------------------------------------
Source                     Sum of Squares      Df   Mean Square     F-Ratio
Model                            5.265639       1      5.265639   27.775844
Error                           1.8957619      10      .1895762
---------------------------------------------------------------------------
Total (Corr.)                    7.161401      11

Correlation Coefficient = 0.857485
Stnd. Error of Est. = 0.435403

Do you want to plot the fitted line? (Y/N):


 1HELP     2LABEL   3SAVSC   4RECORD 5PLTPAR 6        7         8          9REVIEW 10
PRINT      THR OCT 17  1985 10:01:00 AM  VERSION 1.1                          APL REC
```

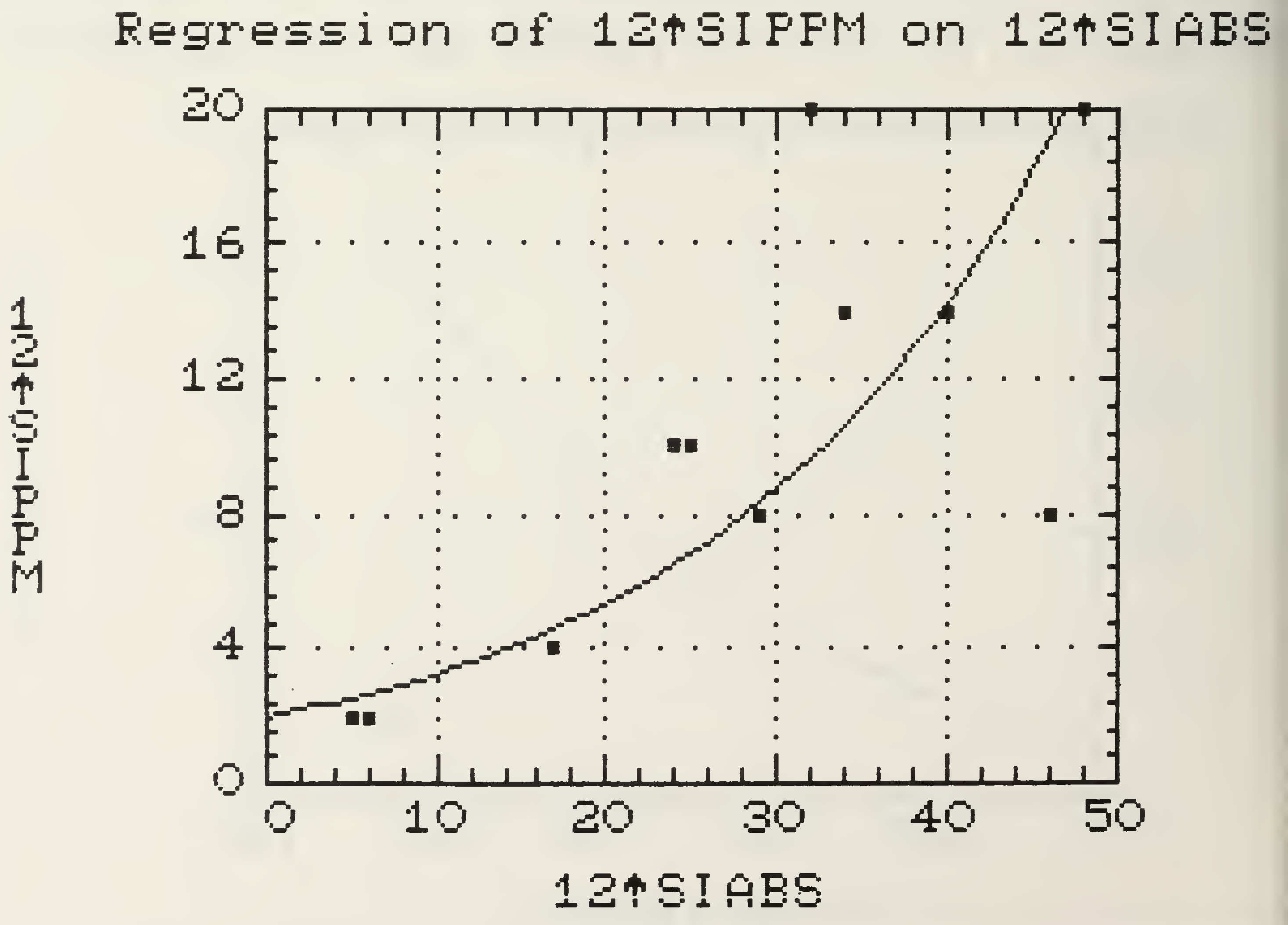


Figure 25

```
BS
                               Standard                   T                Prob.
eter        Estimate            Error                   Value              Level
------------------------------------------------------------------------------------
cept        0.676491           0.173968               3.88859        3.68286E}3
           0.0603773         6.99237E}3               8.63473        1.19672E}5

------------------------------------------------------------------------------------
                          Analysis of Variance
------------------------------------------------------------------------------------
e                    Sum of Squares      Df   Mean Square      F-Ratio
                           5.252711       1      5.252711    74.558628
                           .6340567       9      .0704507
------------------------------------------------------------------------------------
 (Corr.)                  5.8867673      10

lation Coefficient = 0.944612
 Error of Est. = 0.265426

u want to plot the fitted line? (Y/N):


P   2LABEL  3SAVSC  4RECORD 5PLTPAR 6       7          8          9REVIEW 10QUIT
    THR OCT 17  1985 10:08:00 AM  VERSION 1.1                          APL REC:OFF
```

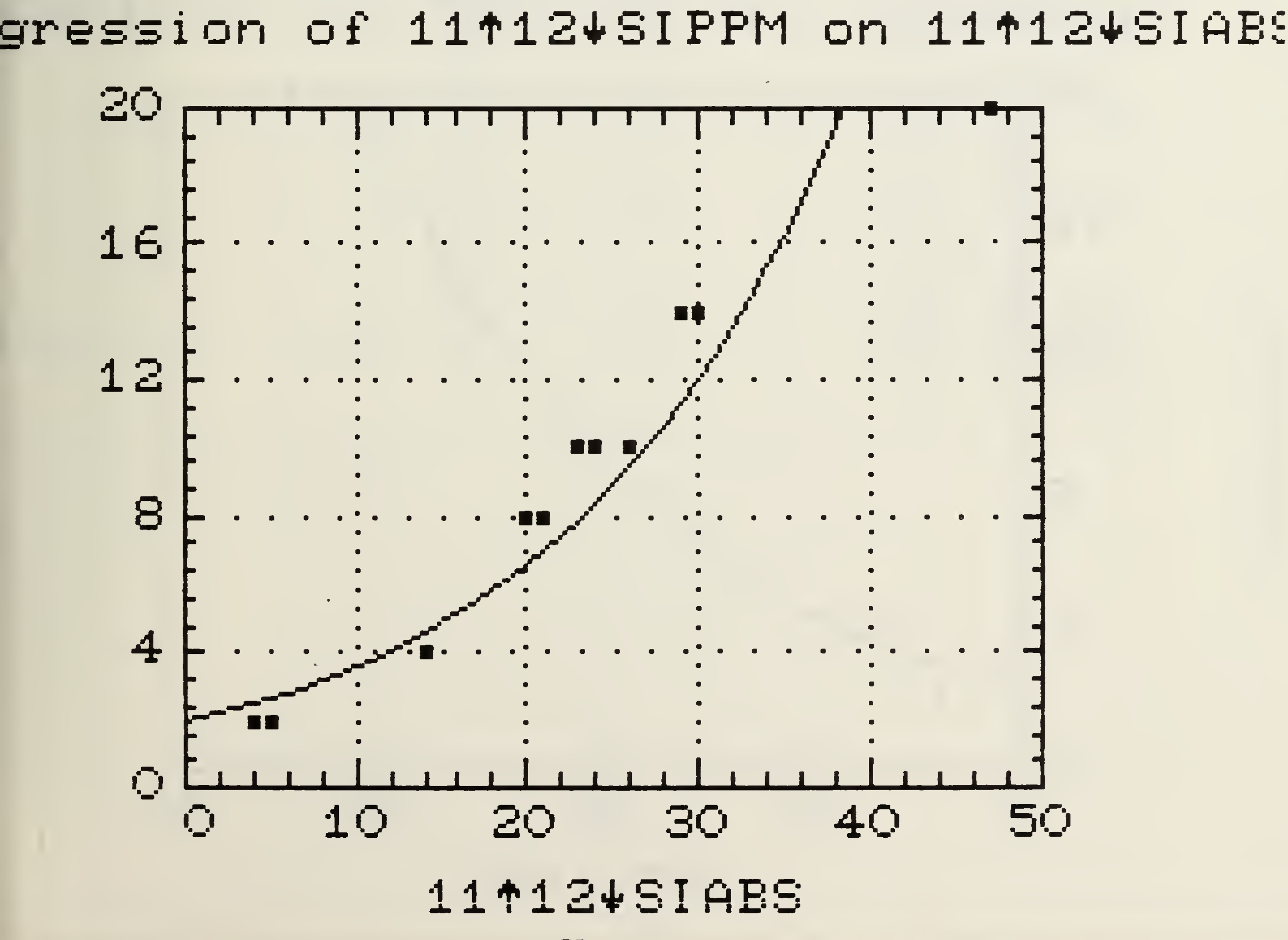


Figure 26

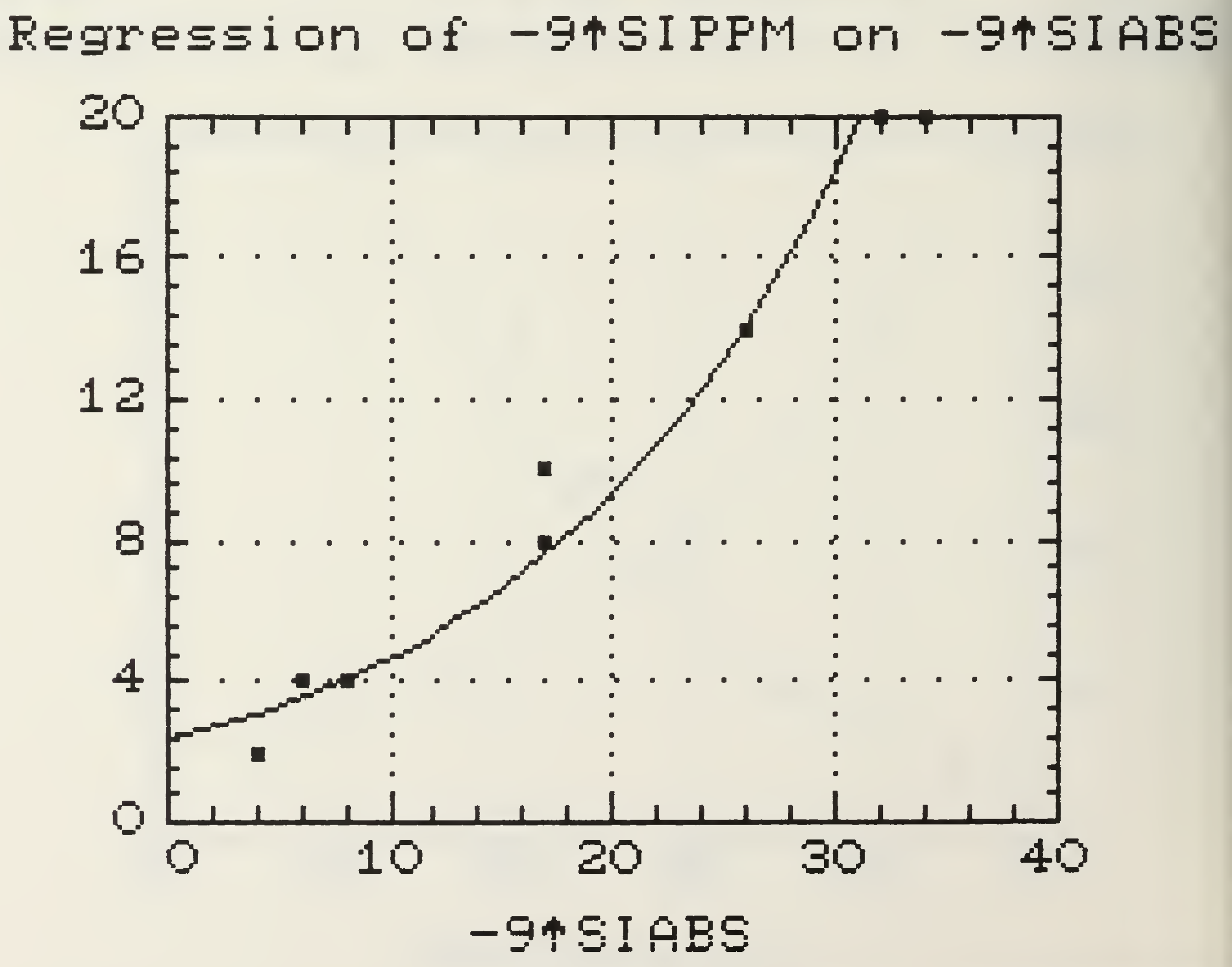
```
SIABS
                                        Standard              T               Prob.
Parameter          Estimate              Error              Value              Level
--------------------------------------------------------------------------------------
Intercept          0.852044            0.160635            5.30423          1.11822E)3
Slope              0.0690216          7.77771E)3           8.87429          4.67397E)5

--------------------------------------------------------------------------------------
                        Analysis of Variance
--------------------------------------------------------------------------------------
Source                     Sum of Squares      Df   Mean Square     F-Ratio
Model                            4.568128       1      4.568128   78.752935
Error                           .4060407        7      .0580058
--------------------------------------------------------------------------------------
Total (Corr.)                   4.9741689       8

Correlation Coefficient = 0.958316
Stnd. Error of Est. = 0.240844

Do you want to plot the fitted line? (Y/N):


 1HELP    2LABEL   3SAVSC   4RECORD 5PLTPAR 6         7          8          9REVIEW 10Q
PRINT     THR OCT 17  1985 10:12:00 AM  VERSION 1.1                             APL REC
```



GRAPHITE TUBE REPLACEMENT DATA

CATION	PWMA NO.	TUBE NO.	BURN NO. AT REPLACEMENT	REASON FOR REPLACEMENT
NGLEY AFB	002	2-1	101	AZ / RESLOPE FAILURE
		2-2	98	NO REASON GIVEN
		2-3	83	CAL II FAILURE
		2-4	43	CAL / AZ FAILURE
		2-5	160	CYCLE COMPLETED
		2-6	160	CYCLE COMPLETED
		2-7	160	CYCLE COMPLETED
RTLE BEACH AFB	003	3-1	2	AZ FAILURE
		3-2	120	CALIBRATION FAILURE
		3-3	120	RESLOPE FAILURE
		3-4	80	RESLOPE FAILURE
		3-5	40	RESLOPE FAILURE
		3-6	40	AZ FAILURE
RF PENSACOLA	004	4-1	1	AZ FAILURE
		4-2	160	CYCLE COMPLETED
		4-3	1	AZ FAILURE
		4-4	160	CYCLE COMPLETED
		4-5	40	AZ FAILURE
		4-6	160	CYCLE COMPLETED
		4-7	160	CYCLE COMPLETED
		4-8	1	AZ FAILURE
		4-9	160	CYCLE COMPLETED
		4-10	160	CYCLE COMPLETED
		4-11	1	AZ FAILURE
		4-12	1	AZ FAILURE
		4-13	160	CYCLE COMPLETED
		4-14	160	CYCLE COMPLETED
MENDORF AFB	005	5-1	160	CYCLE COMPLETED
		5-2	160	CYCLE COMPLETED

Table 41

DISTRIBUTION OF THE GRAPHITE TUBE REPLACEMENT TIMES

We analyzed the data on the burn numbers at which graphite tubes were replaced in the PWMA either due to malfunction or because a full cycle of 160 burns has been completed. This analysis is based on the portion of the PWMA field test completed so far. Complete details on the times of replacement and the reasons for replacement are in the Table 39.

The observed replacement times, in ascending order were 1,1,1,1,1,1, 2,40,40,40,43,80,83,98,101,120,120,160,160,160,160,160,160,160,160,160,160, 160,160,160,160,160,160,160,160. This data indicates that a graphite tube is defective at the outset with probability .17 and the probability that a tube needs replacement before completion of a 160 burn cycle is .486. The observed cumulative frequency distribution of the burn number at which tube replacement occurred is presented below.

Burn Number	Observed Cumulative Frequency
1	6/35 = .171
2	7/35 = .200
40	10/35 = .286
43	11/35 = .314
80	12/35 = .343
83	13/35 = .371
98	14/35 = .400
101	15/35 = .429
120	17/35 = .486

Table 42

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